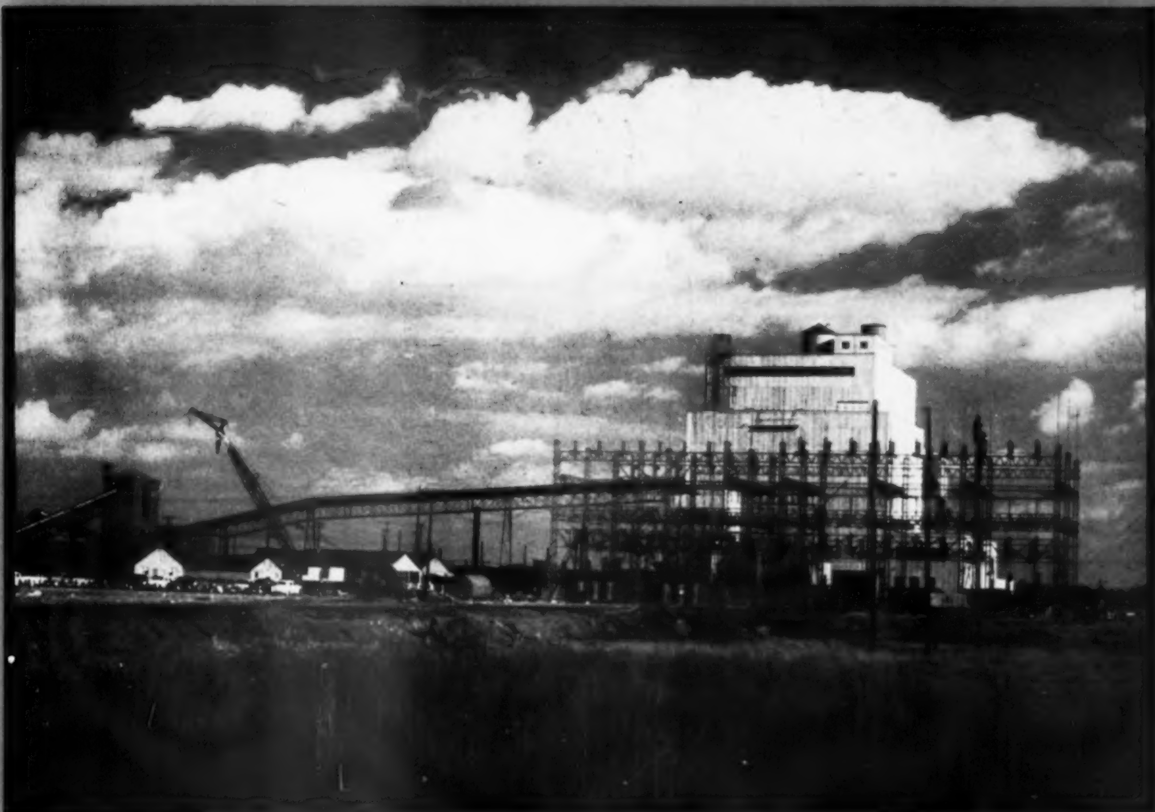
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

May 1953



Photograph by Harry Bishop

New Portsmouth Station of Virginia Electric and Power Company

New Kearny Station in Service

Effects of Temperature on Steam Turbine Oil

3,000,000 Kw Reheat Operating Experience

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COMBUSTION

Editorials

Puff vs. Explosion

There was a time when boiler explosions were commonplace; but with the advent of the ASME Boiler Code, advances in the technique of fabrication, inspection and operating practice, they have become a rarity, notwithstanding spectacular increases in pressure and temperature. Nowadays such accidents are largely confined to low-pressure heating boilers operated without due regard to maintenance.

Of course, with both pulverized coal and gas firing, furnace puffs are occasionally reported despite the installation of safety measures. They are often traceable to some human factor and the damage may be slight or appreciable, but not destructive compared with that of a boiler explosion involving rupture of pressure parts.

Yet, regardless of the extent and the facts, it is usual for the daily press, to headline the occurrence with the title "Boiler Explosion." This creates unjustified apprehensions.

When Does a Prime Mover Become "Conventional"?

At the ASME Spring Meeting recently held in Columbus, Ohio, much interest centered in a group of papers describing potential power-plant applications of the free-piston gasifier. The discussion had not proceeded very far until it became evident that a formal distinction should therefore be made between the combustion gas-turbine power plant and the free-piston gas-turbine power plant. As it turned out, what could be more natural and more obvious than using the term "conventional" in referring to the combustion gas turbine?

Yet in thinking about the matter one is struck by the ready acceptance of this designation for a type of prime mover in which American central-station experience amounts to but a few years. Looking back over the history of engineering developments, is it not true that the time element in going from the "new" to the "conventional" has been on the order of decades and sometimes even of centuries?

Speaking at the same ASME Meeting, Everett S. Lee, editor of *General Electric Review*, placed another type of perspective on the rapidity of technological developments. Going back to the year 1935 he enumerated the following items, some of which had been discovered or were in existence at the time, which today have widespread application: atomic energy, nylon and other synthetic fibers, radar, television, continuous-flow chemical plants, diesel-electric and gas-turbine-electric locomotives, high-octane gasoline, silicones, synthetic rubber, penicillin and the antibiotics, ACTH and cortisone, the jet engine, magnesium and titanium for structural use, the electronically controlled automatic machine tool, the forked truck, the electronic computer, the germanium diode and the transistor. Most of these represent new doors opened by the engineer with the aid of the scientist.

In this accelerated pattern of technical advance it is not surprising that the "new" gives way to the "conventional" with scarcely a murmur of astonishment among the engineers who are responsible participants in today's achievements.

Government Projects Will Require Vast Coal Tonnage

Despite the fact that consumption of coal by the electric utilities shows only a relatively small month-to-month increase compared with that of competitive fuels, there is every reason to believe that coal will long continue as the basic fuel in power production. This belief is predicated on approximately two-thirds of the present utility stations and those now building having been designed to burn coal; also, the vast tonnage now involved in power for defense projects.

Addressing the recent Annual Meeting of Bituminous Coal Research, President A. A. Potter observed that the demands for electric energy by our Government are certain to assume large proportions, since the annual coal requirements of TVA, which is now engaged in constructing a number of large steam plants, are estimated to increase from two to twelve million tons within the next few years, and those of the various plants serving the Atomic Energy Commission are expected to exceed twenty-two million tons annually when the present expansion program is completed.

Obviously, total fuel consumption, whether coal, gas or oil, will increase at a rate somewhat less than that of electrical output because of technological advances in the art of power generation, but this should not discourage the coal industry.

NEW KEARNY STATION IN SERVICE

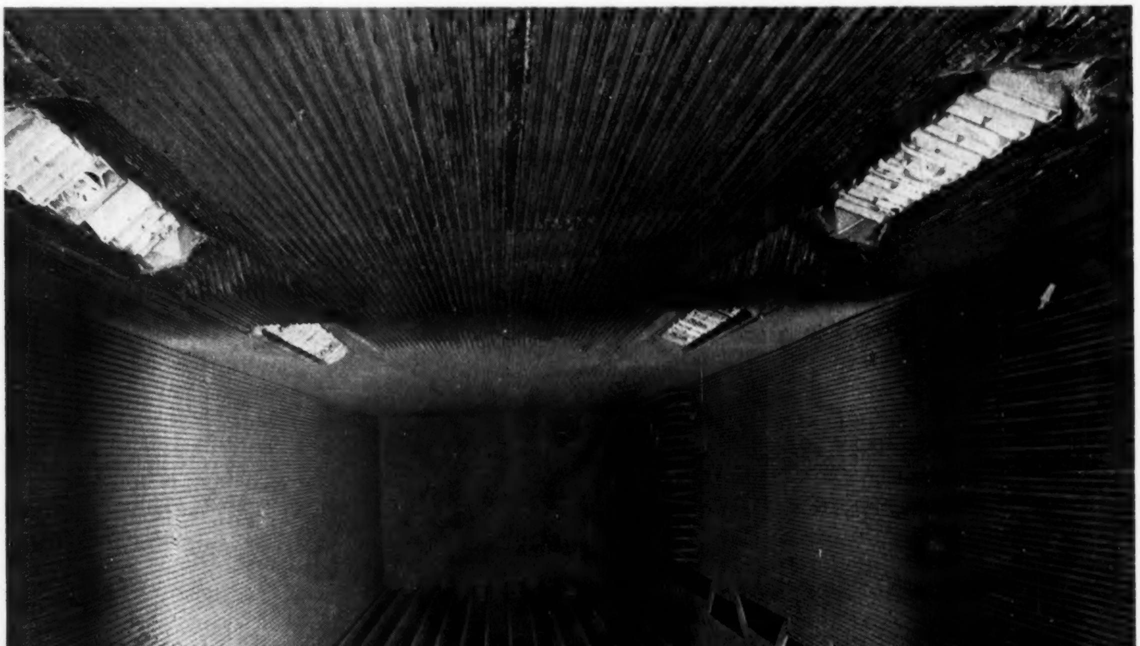
Some Features of the Steam Generating Units Employing Highest Pressure and Temperature

DISTINCTION for operation at the highest steam conditions of 2350 psig and 1100 F with 1050 F reheat attaches to the new Kearny Generating Station of the Public Service Electric & Gas Company. The first unit was placed in service on March 30 and the second is scheduled for operation in September.

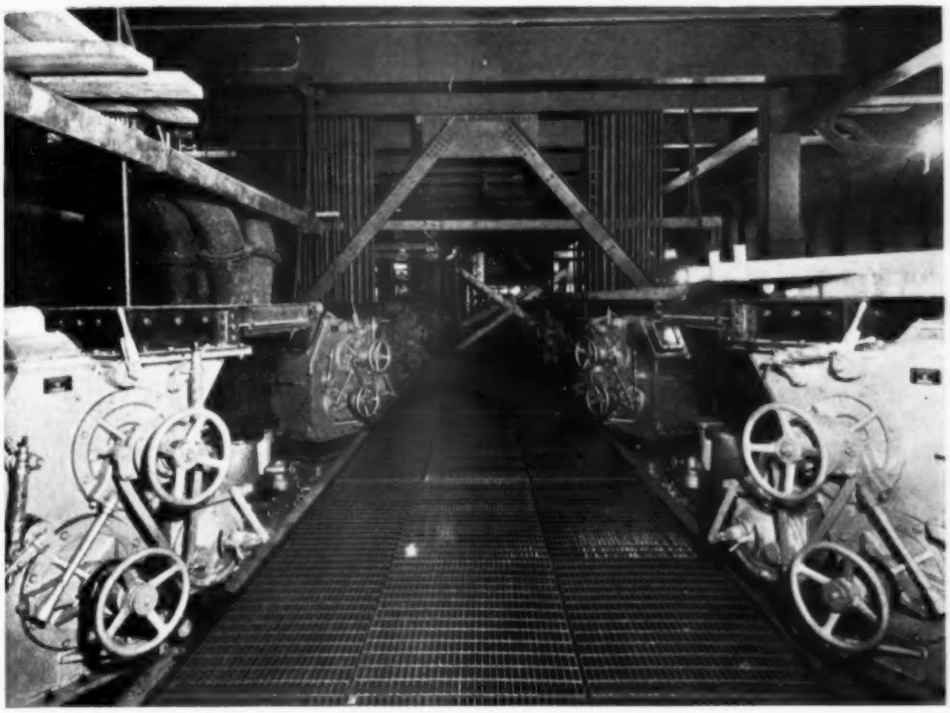
The original Kearny Station, located on the Hackensack River at Kearny, N. J. which is still in active service and adjacent to the new station, was placed in operation in 1925. At the time it was the first large installation to employ the 400-lb American Engineering Standards for steel piping and one of the earliest stations to use, wherever possible, forge-welded construction to minimize or eliminate fittings and pipe joints. Also, a few years later, it became the second central station to employ a mercury-steam unit.

A brief review of some of the high spots of the original installations may be of interest in comparison with the new station, as revealing certain advances in practice over the last 28 years. It contained initially twelve 230,000-lb per hr sectional-header boilers supplying steam at 340 psig, 700 F to three 40,000-kw and two 50,000-kw turbine-generators. These boilers were stoker-fired and within the next two years there were added three 325,000-lb per hr boilers which were also stoker-fired. A 90,000-kw turbine-generator was installed in 1932 at which time the 20,000-kw mercury-steam unit was put in. Two of the earlier units were rerated in 1942 to 52,000 kw, thus bringing the capacity of the original station up to 334,000 kw.

The initial capacity of the new station is 290,000 kw in two boiler-turbine units.



View looking up into one half of furnace, showing platen-type superheater and division wall at right. The light color of the upper walls is due to a thin coating of ash when burning oil; coal had not yet been burned



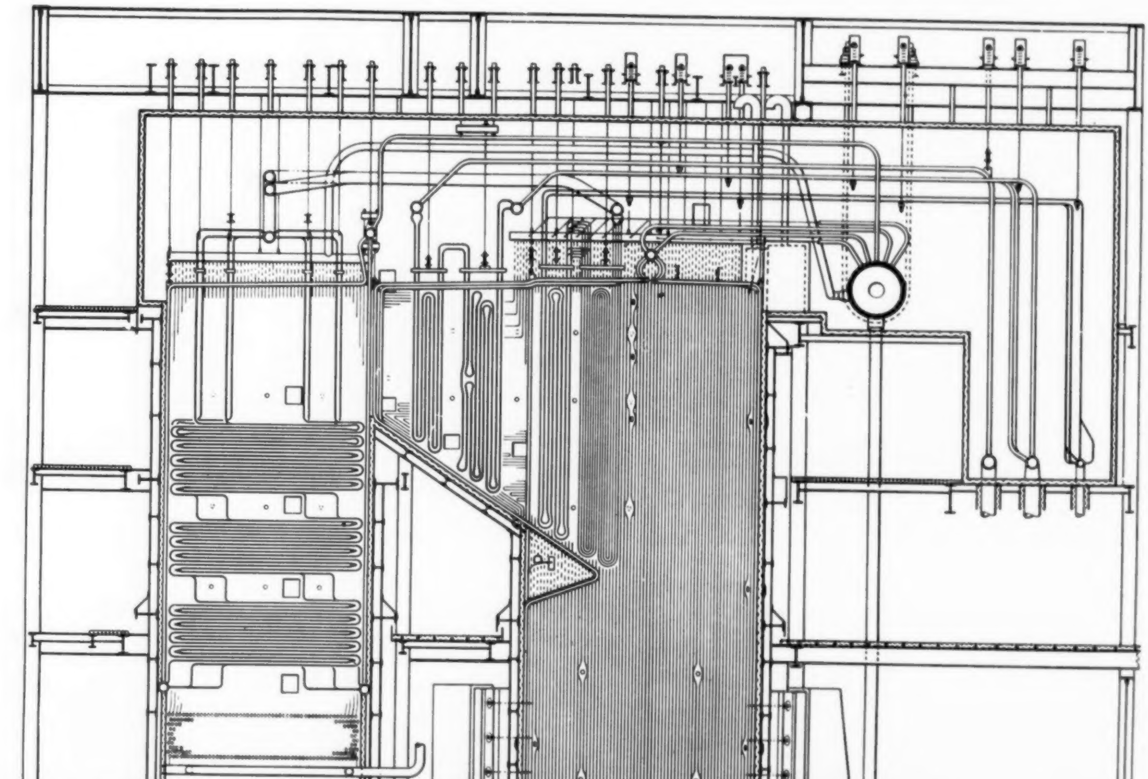
Pulverizer feeder aisle looking West

High-Pressure Steam Generating Units

These are of the Combustion-Engineering controlled-circulation, semi-outdoor type with fully water-cooled, divided furnaces of the continuous-discharge wet-bottom type. The divided furnace provides maximum heat-absorbing surface for a given total combustion volume and more favorable furnace proportions for each side. However, as will be seen from the accompanying photograph, there are large openings in the dividing wall which serve to equalize the pressure on the two sides of the furnace.

Although designed for pressurized operation the boilers are provided with induced-draft fans for use when necessary. The superheaters are of the two-stage Elesco channel, or platen type, with widely spaced elements to minimize fouling. The reheater in each unit is located between the primary and secondary superheaters which are followed by the economizer. At the bottom of the rear pass of each unit ducts lead to two regenerative air preheaters of the Ljungstrom type. Tangential firing is employed with the burners arranged in three tiers, the top for oil and the two lower for coal and natural gas. These burners are located in the front and rear walls of each furnace, near the corners. Four C-E Raymond bowl mills of new design for pressurized operation, and of 36,000 lb per hr nominal output, are installed per boiler,

Pulverizer aisle showing the eight mills for serving two boilers



Section through steam generating unit showing location of mills and, at the right, the circulating pumps

with the pipes arranged so that each mill feeds two opposing burners in each half of the furnace.

Each unit is designed to supply steam to a 145,000-kw General Electric tandem-compound triple-exhaust, turbine-generator having stop-valve conditions of 2350 psig, 1100 F initial temperature and 390 psig, 1050 F reheat. The maximum continuous rating of each steam generating unit is 955,000 lb per hr with an accompanying reheat flow of 800,000 lb per hr. Design drum pressure is 2650 psig and at maximum continuous rating the calculated efficiency is 89.4 per cent. When operating at full load each unit will consume fuel at an estimated rate of approximately 1100 tons of coal or 5200 bbl of oil per day.

The furnace-walls are made up of $1^1/_2$-in. and $1^5/_8$-in. plain tubing having a wall thickness of about 0.2 in., the larger diameter tubes being employed for the center dividing wall. The wall tubes were shop-welded into panels.

It is of interest that there are nearly 20 miles of tubing in the furnace of each unit and approximately 50 miles in the superheater and reheater. Thus, exclusive of the economizer, each steam generating unit contains nearly 70 miles of tubing.

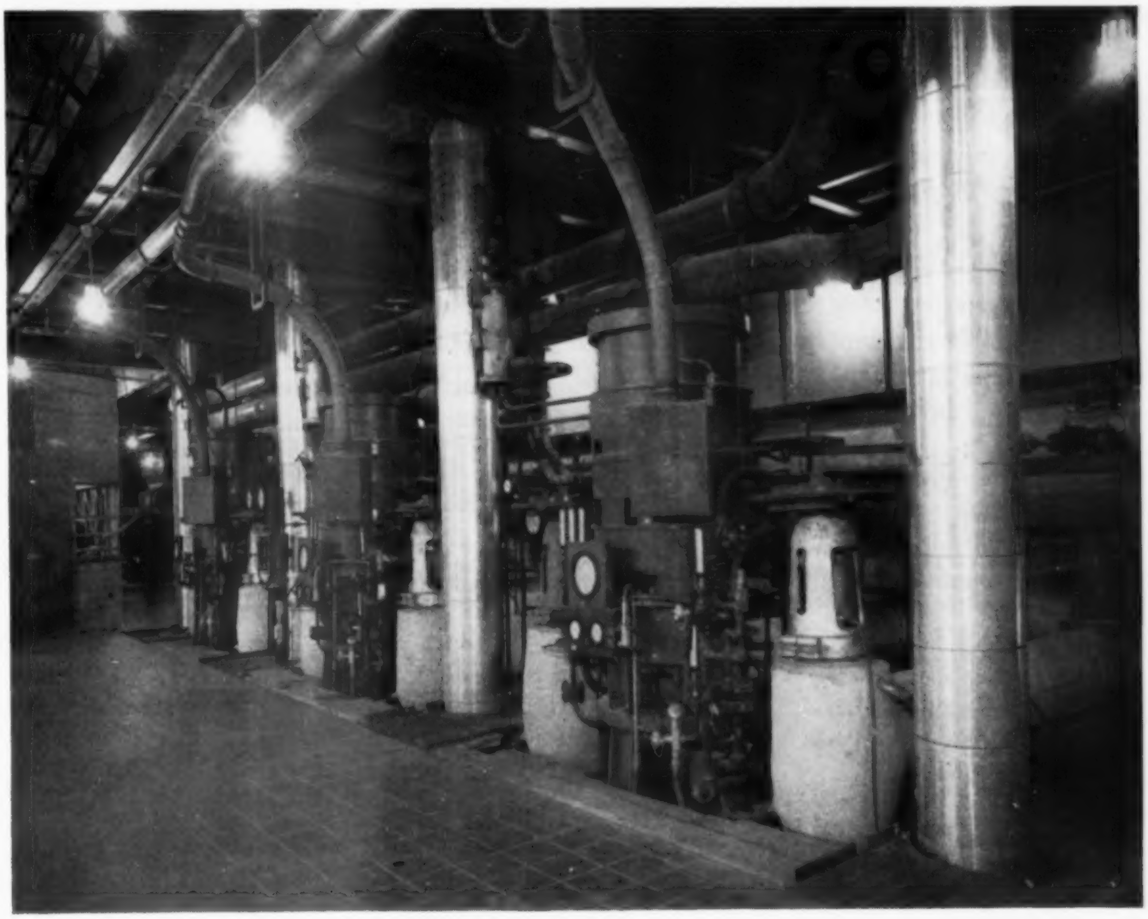
The single steam drum is 54 in. diameter, in addition to which there is a small bottom distribution drum that receives all the water from the discharge of the boiler circulating pumps. In it are located the strainers and orifice plates, easy access to which is thus provided.

A combination of steam-cooled wall tubes and economizer surface at the rear permits the elimination of suspended refractory wall surface in that part of the unit. The economizer has 28,300 sq ft of heating surface with gas flow downward and water flow upward. Each Ljungstrom regenerative-type air preheater has 67,500 sq ft of heating surface.

Some flue gas is introduced into the furnace to increase the mass flow and thus keep the furnace outlet gas temperature down to a value that should avoid slagging of the superheater. When burning oil it assists in maintaining the designed steam temperature. However, both the primary and the reheat steam temperatures are controlled by spray desuperheating.

Each unit is provided with three pumps for controlled circulation, one of these serving as a reserve. They are of the vertical, single-stage design and are driven by constant speed motors. Feedwater from the economizer is discharged into the main steam drum where it mixes with the re-circulated boiler water and enters downtake pipes which are connected to form a junction header on which the suction valves and the circulating pumps are mounted. These pumps are designed to handle 7300 gpm at 40 psi differential head. A circulation ratio of 4 is normal.

Of the fuels expected to be burned, the eastern bituminous coal will run about 38 per cent volatile, 9 per cent ash, 3.4 per cent sulfur, 2050 F ash-fusion temperature and a heating value of 13,225 Btu per lb. The Bunker C oil will have approximately 2 per cent ash and analyze slightly over 18,400 Btu per lb as fired. The natural gas is expected to average about 1035 Btu per cu ft at 60 F.



Boiler circulating pumps for first unit

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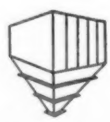

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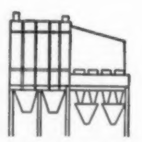

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Effects of Temperature on Steam Turbine Oil

By THOMAS L. BYRNE

Some reminiscences of more than thirty-five years' association with the sale and servicing of turbine oils in both the marine and stationary power-plant fields. Factors responsible for deterioration of the oil are discussed and some conflicting or confusing recommendations are cited.

THE industrial power engineer or the marine engineer who is confronted with a problem in turbine lubricating oil will find that there is available much published material on the subject in engineering textbooks and papers before various groups, as well as in refinery publications and those of turbine manufacturers. Most of these give basically sound advice, but frequently the subject is presented with personal experiences magnified. All too often the authors of such papers are influenced by references to the voluminous material available, much of which moves in trends, first stressing the importance of one condition and then another.

A recent publication put out by a well-known turbine builder states, with reference to deterioration of turbine oil, that "water is the worst offender." After thirty-six years' association with turbine operation, thirty-two of which were in intimate contact with turbine lubrication, the writer finds it impossible to disagree with a statement concerning the evils of water contamination. But the catalytic effects of iron and copper and auto-catalytic deterioration, due to contaminated oil serving as a catalyst to promote further deterioration, also are frequently factors whose importance cannot be denied.

It should be borne in mind that a barrel of lubricating oil from the modern refinery is a masterpiece of the refiner's art. As manufactured, it represents the ultimate in petroleum engineering science, and the result of coordinated effort of great laboratories some of which represent investments of millions of dollars. One cannot improve the original product by straining, heating and centrifuging.

Some of the means employed to prevent deterioration of turbine oil have bordered on the fantastic. For example: in one case where moisture was present in visible quantities in a gravity tank, it was recommended that the water be *boiled* out. This recommendation was supported by the plausible contention that, inasmuch as water boils at 212 F at sea level, the oil will not even give off a semblance of vapor for more than 100 deg higher. An engineer who was in responsible charge of a 12,000-hp marine plant had continued this practice for more than 25 years.

Another theory advanced was that only a small percentage of the oil would form sludge and when this was removed only the purer elements would remain. From this theory came the development of "desludging" apparatus, intended to create sludge and remove it, with the idea of improving the oil to a greater degree than the refinery had done. A steam jet generally did the sludging job. The original proponents of this idea quickly discovered the error, but the theory carried on for a long time in remote places.

Effects of Heat

It is the purpose of the present discussion to stress the importance of avoiding unnecessary exposure of turbine-system lubricating oil to excessive heat regardless of high temperatures that may prevail in the power plant.

All lubricating oils have a tendency to combine chemically with oxygen and form petroleum acids, and then form sludge. Heat is the most active agent in accelerating oxidation of the oil, the rate of change depending on the amount of heat, the length of exposure and the presence of other factors such as moisture, a catalyst and/or oxygen.

With increased use of high-temperature steam many changes in materials and practices have been necessary. The following example in the field of marine power-plant lubrication is worthy of note.

A new vessel operating with steam at 475 psig, 200 deg F of superheat, and with auxiliary steam from the desuperheater reduced through successive stages for different uses to 10 psig, was using the lowest pressure steam to heat the lubricating oil before centrifuging. The heater, a type in general use, employed a $1^1/_2$-in. pipe enclosed concentrically in a 4-in. pipe with counterflow steam flow through the inner pipe and oil through the outer. It was discovered that the oil after leaving the centrifuge was worse than when entering the heater. Refinery men refused to believe, at first, that oil at a temperature (entering the centrifuge) even as high as 180 F could "burn." When it was indicated that skin temperature where the oil came into direct contact with a hot pipe overheating, it was agreed that the oil "might fry a little."

It was natural to reach for steam tables to determine the steam temperature at the reduced pressures, but investigation revealed that temperatures were abnor-

The author has recently retired from the Sinclair Refining Company after more than thirty years' service, supplemented with operating experience in the Navy and Merchant Marine during both World Wars. His experience also extends to industrial power plants.—EDITOR

mally high all along the line and on the 10-psig line the temperature was 410 F, whereas the steam tables showed a temperature of 240 F for 10 psig steam. While the answer appears obvious, it was completely unnoticed at the time.

Much of this experience occurred at the time the industry was undergoing transition from straight mineral oil to additive type turbine oils. Changes of this sort are slow for many reasons, but often the net result of prevailing conditions was rapid deterioration of the turbine system oil.

The rate of oxidation of oil is considered, roughly, to double for each 18 deg F increase in oil temperature, where all other conditions remain the same. In fact, near the beginning of World War II a turbine lubrication booklet published by an oil company then pioneering in additive oil, contained the statement that for each 18 deg F temperature rise above 140 F the rate of oxidation would double. Also, a paper under the authorship of three chemical engineers of this same company stated: "Like most chemical reactions oil oxidation is sharply accelerated by a rise in temperature. The best oil maintained at the oil stability test of 95 C (203 F) lasts several months, but if held at 150 C (302 F) under oxygen pressure in the presence of water and catalytic metals, the life becomes a matter of hours."

Further on, in reference to the temperature of oil in settling tanks, the paper stated that "it is advisable not to exceed a temperature of 55 C (131 F) in the oil settlers, in order to avoid unnecessary contamination."

Before considering temperature reduction it is well cautiously to avoid going too far. In a paper by a turbine builder's representative, published in June 1949, the following statement appeared: "Experience indicates that with temperatures of approximately 120 F of oil to the bearings, of 130 F minimum tank temperature and of 140 F to 163 F bearing outlet temperature, a balance exists to give best service performance." Then the author added, with due caution, that with the inhibited oils, some people are recommending even higher operating temperatures.

However, referring back to his company's installation handbook of 1943, the same author stated that most turbine oils at a temperature of 120 F or less will maintain water in suspension, but that they will not maintain water in suspension at a temperature of 130 F or above.

Combining the knowledge that water can be settled out by gravity at 130 F with the oil company's opinion concerning accelerated oxidation at temperatures beyond 140 F, and adding to this the increases over the force of gravity obtained in centrifuges, it can be seen that heavier contaminants, including water, can be removed without promoting further contamination by application of unnecessary heat.

In one case the oil from the cooler was found to be better than that in any part of the system. When the causes were discovered the engineer stated, "as long as I am in charge, the purification system will operate, and before I put a barrel of new oil into my turbine system it must go through the purifier."

The purification process in this case was as follows: The gravity tank was fitted with a heating coil using 430-F steam, and the oil was heated to 224 F to boil out possible water. Steam at 420 F maintained 220 F as the oil entered the centrifuge. A misplaced gasket made water sealing impossible in the centrifuge which was compensated for by a $^1/_4$-in. copper line supplying water to the centrifuge from the hotwell containing condensate carrying boiler water treatment that was harmful to the oil.

Again, it may be pertinent here to consider the operating experience of two tanker fleets, one of which maintains temperatures of 140 F to 160 F entering the centrifuge, the other 160 F to 180 F. In the case of the former, oil in service three to five years has shown little or no change; whereas the same oil in the other vessels, while giving excellent performance, shows visible change.

Suggested Procedure

1. Where bearing temperatures are maintained at the recommended 140 to 160 F, the turbine-bearing-oil drains may be fitted with a bypass to an insulated tank used to feed the centrifuge by gravity or pump, as the case may be. This method would be used where frequent or steady centrifuging is required or desired.
2. When the upper temperature in the turbine room exceeds 140 F, centrifuge the oil directly from the tanks.
3. To provide for the very necessary centrifuging of the oil from the low point of the sump tank, which in marine practice is generally sloped, it will frequently be necessary to provide heat. A hot-water heater with temperature maintained at 160 F and with sufficient heating surface to deliver an ample supply of oil to the centrifuge at temperatures above 140 F will assure the operator that no deterioration of the oil is occurring during the rehabilitation process. However, under many present operating conditions it is quite possible that the cure may be worse than the disease.

The subject is thought provoking. One authoritative source states that "the oxidation of highly refined mineral oils proceeds in general by an autocatalytic mechanism." This action progresses as contaminated oil serves as a catalyst to deteriorate good oil. In the presence of copper, and to some extent in the presence of steel or other metals, catalytic action occurs accelerated by the presence of moisture, oxygen and heat.

Quoting again from a paper by a turbine builder's representative "the flash point of turbine oils is between 330 F and 400 F and the fire point is approximately 40 F higher. The auto-ignition temperature of turbine oils is from 650 F to 700 F, the auto-ignition temperature being the lowest temperature to which a mixture of flammable vapor and air, or a surface exposed to the mixture, must be heated to ignite the mixture in the absence of a spark or flame."

The issue is clouded by the statement that the oil reaches "cracking" temperature at 600 F or approximately that temperature.

However, at temperatures between 425 and 450 F, at close to maximum and in some cases as low as 330 F, the marine turbine oils give off an ignitable vapor, and a visible change occurs. The changes that occur at the lower temperatures are visible in sludges, acids and oxidized oil.

It appears then that lower temperatures in lubricating oil heaters are indicated.

3,000,000 Kw Operating Experience with Modern Reheat*

By OTTO DE LORENZI†

THE trend toward reheat, as discussed in a paper[1] presented before the Midwest Power Conference during 1951, continued unabated through 1952. In fact, this as a trend has now been terminated through the almost universal acceptance of reheat for new installations.

Between January 1, 1946, and January 1, 1953, a total of 221 units having an aggregate rated electrical capability of 27,582,000 kw, in sizes ranging from 40,000 to 250,000 kw, were on order, under construction, or in operation. Of this number 105 units, totaling 14,475,000 kw, were ordered between March 1, 1951, and January 1, 1953. Table 1, in addition to showing size distribution of these units, also provides information on throttle pressures and primary steam temperatures.

TABLE 1—REHEAT UNITS, JAN. 1, 1946, TO JAN. 1, 1953

	Jan. '46 to Jan. '50	Jan. '50 to Mar. '51	Mar. '51 to Jan. '53	Total
No. of units	34	82	105	221
Max. capability, mw	3,417	9,690	14,475	27,582
Unit size, kw				
40,000	..	..	2	2
62,500	5	4	2	11
75,000	10	13	7	30
100,000	9	19	21	49
125,000	3	25	18	46
150,000	7	17	27	51
175,000	..	..	3	3
200,000	..	4	23	27
250,000	..	..	2	2
Throttle press, psig				
1250	3	3	2	8
1450	23	40	31	94
1800	1	33	53	87
2000	7	4	18	29
2300	..	2	1	3
Primary steam temp., F				
950	6	3	..	9
1000	20	67	66	153
1050	8	10	38	56
1100	..	2	1	3

Design Characteristics

Since August 1949 approximately 3,000,000 kw of C-E reheat units have been placed in commercial service. With but one or two exceptions all have the same fundamental design characteristics, regardless of pressure, primary and reheat steam temperature, capacity or fuel used. Thus, actual differences between installations are reduced to providing sufficient furnace volume together with proper proportioning and distribution of heat-absorbing surface, so as to avoid excessive furnace-leaving temperature or use of large quantities of spray water for steam temperature control. Many of the design characteristics which lend themselves to this type of standardization are illustrated in Fig. 1.

Tangential firing with tilting burners in a fully water-cooled, hopper-bottom furnace is used for such units. The superheater is divided into two banks. The primary or low-temperature stage consists of a series of horizontal loops installed in the gas pass immediately above the economizer. The secondary or high-temperature stage comprises a vertical bank with elements spaced on wide centers and located at the furnace outlet, behind a row of widely spaced wall tubes. The reheater section, which also consists of vertical elements on somewhat closer centers, is located interstage between the two superheater banks. Two spray-type desuperheaters are provided, one between the low- and high-temperature sections of the superheater and the other at the reheater inlet.

Steam Temperature Control

Fundamental design concept of these units is to maintain reheat steam temperature at a constant level, throughout the normal operating range, by vertical adjustments of burners. Any excess temperature of primary steam is then corrected through use of spray-water injection in the interstage desuperheater. Selective cleaning of furnace waterwall surfaces is also used to effect changes in both primary and reheat temperatures.

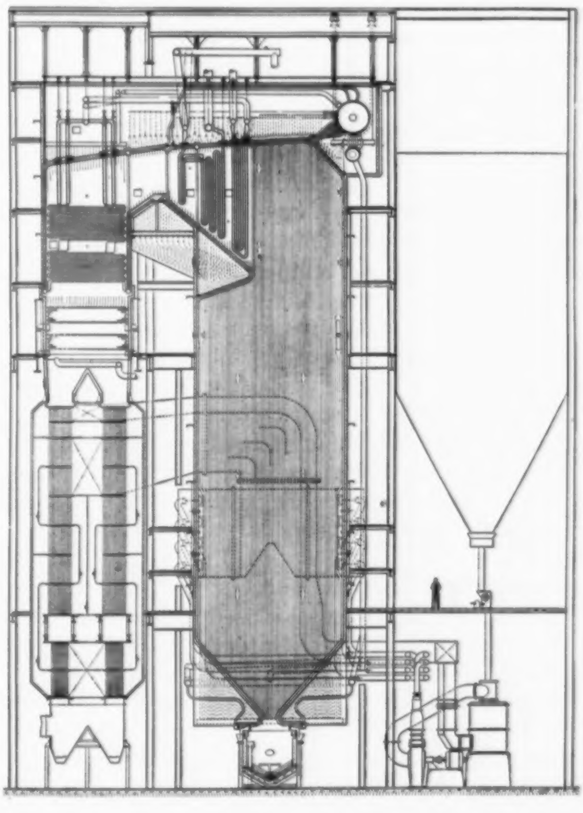

Fig. 1—One of two 100-mw C-E reheat units installed at Meramec Station of Union Electric Company, St. Louis, Mo.

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* A paper presented at the American Power Conference at Chicago, March 25–27, 1953.

† Education Director and Fuels Consultant, Combustion Engineering, Inc.

[1] "The Trend Toward Reheat" by H. G. Ebdon. See COMBUSTION, Vol. 22, No. 10, April 1951.

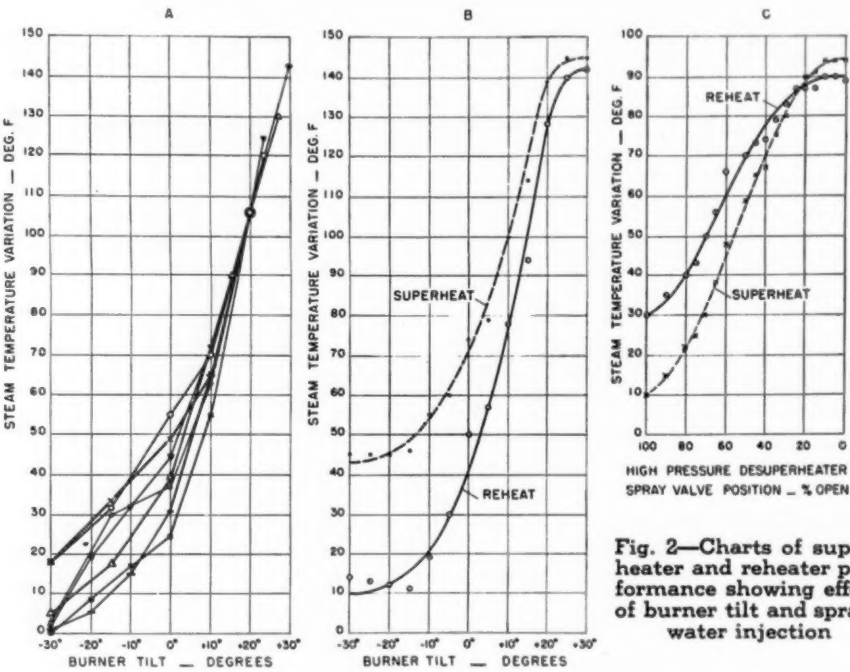

Fig. 2—Charts of superheater and reheater performance showing effect of burner tilt and spray-water injection

Reheat units appear to be complex only because of differences in heat-transfer requirements of the superheater and reheater. Inasmuch as the superheater is supplied with saturated steam, the amount of heat added per pound, at all loads, remains the same for constant temperature at the outlet header. Feedwater temperature to the unit will, however, vary with changes in turbine capacity and thus result in a change in the ratio of total heat input to the unit to gas flow over the superheater per pound of steam generated. To maintain constant steam temperature, it is, therefore, necessary to vary gas temperature at the superheater inlet.

Conditions for reheater operation, however, are quite different because temperature and pressure of the steam at the high-pressure-turbine exhaust decreases with reduction in capacity. The heat added to produce constant temperature at the reheater outlet header must, therefore, be increasingly greater as capacity falls off. Thus for constant steam temperature from both superheater and reheater, gas temperature at the furnace outlet should simultaneously have a falling as well as a rising characteristic with decrease in capacity. Since these conditions are impossible to obtain with a single furnace, the surfaces are proportioned so as to require the same furnace temperature at maximum capacity. Furthermore, the high- and low-temperature banks of the primary superheater are designed to minimize differences in gas temperature requirements at partial loads. With this arrangement steam temperature at the reheater outlet is then used to regulate furnace temperature by tilting the burners, and steam temperature at the superheater outlet is used to meter the amount of spray water needed for interstage desuperheating. The desuperheater installed at the reheater inlet is a safety device for use during abnormal operating periods only. Thus, should the heat-absorbing surfaces of the furnace or superheater section become excessively coated with sintered dust because of lowered ash-fusion temperature, owing to change in coal or because of failure to properly operate and maintain the soot-blowing system, then the gas temperature condition would make it necessary to use some spray water in the reheater. Any emergency trip-outs which result in fast shutdown of the unit would call for some use of sprays at the reheater inlet to keep temperature under full control.

Furnace-Outlet Temperature Control

Inasmuch as control of furnace-outlet temperature plays such an important part in superheater and reheater performance, it is necessary that the operator be provided with means for producing, quickly, the degree of regulation needed to meet ever-changing load conditions. With tangential firing and vertically adjustable burners it is possible to change furnace-outlet temperature by selective positioning of the highly turbulent zone of combustion. Owing to sweeping action of the flame envelope over water-wall surfaces, a greater heat absorption is obtained, through combination of radiant and convection transfer, than with any other type of firing. Furthermore, because furnace-outlet temperature is a direct function of heat-release and heat-absorption rates per square foot of exposed water-cooled surface, it is possible to obtain a wide degree in gas-temperature change through the use of burner tilt for making relative variations in areas of heat-absorbing surface employed. This raising and lowering of the fuel-burning pattern will provide an approximately constant 250-deg F furnace-outlet temperature difference, throughout the range from 100 per cent capacity down to well below 40 per cent, between fully elevated and fully depressed burner positions. The major portion of actual control, however, is obtained above horizontal burner position. Furnace-outlet temperature at maximum capacity with horizontal burner position is used for proportioning superheater and reheater surface. Temperature regulation available between horizontal and full downward tilt may be used for over-capacity operation or to compensate for any effect of sintered dust on the walls and thereby provide an operating safety margin. The range of tilting burners, when necessary, may be further

extended through the supplemental use of gas recirculation.

Steam Temperature Over Wide Capacity Range

The reheat unit at Russell Station of the Rochester Gas & Electric Corp. is operated under wide capacity variations between 9 mw and 69 mw with corresponding steam flow of 60,000 to 470,000 lb per hr at 1465 psi. Constant superheat and reheat temperatures of 1000 F are maintained from 27 mw to 69 mw. Minimum temperatures at the lowest load point are in the vicinity of 850 F. Tilting burners, without the use of spray water in the reheater and with a minimum quantity for superheat control, made this wide-range operation possible. Had fixed type burners been used, it would have been necessary to over-surface both the superheater and the reheater so as to obtain full temperature at the 27-mw load point and then with load upswing use increasing quantities of spray water in them.

Effect of Burner Tilt and Spray-Water Injection

Data from several large high-pressure utility installations are presented in Fig. 2 to show the actual effect of burner tilt and spray-water injection on superheater and reheater performance. The family of curves, Fig. 2-A, obtained from once-through installations represent steam temperature change at the superheater outlet resulting from use of full-range burner tilt with the units held at constant output. In each instance temperature change is approximately 130 deg F. and this, in turn, checks closely with a furnace-outlet temperature change of 250 deg F.

The pair of curves shown in Fig 2-B, are from a reheat installation similar to that illustrated in Fig. 1. Constant capacity was maintained throughout this test. Changes in superheater and reheater outlet temperatures were obtained through use of full-range burner tilt. Temperature drop for the reheater is increasingly greater than for the superheater. This condition is somewhat analogous to what occurs when capacity falls off. Under this latter condition burners must be tilted upward to maintain reheat temperature, with the result that primary superheat becomes too high unless some spray water is used to keep it below a predetermined limit. The actual amount of spray water used for primary desuperheating is a function of per cent capacity at which the unit is operated. Normally it is less than 1 per cent of the primary steam flow at 80 per cent capacity; at 50 per cent capacity it may reach 2 per cent.

The following performance data were obtained from a 750,000-lb per hr unit which has now been in service for more than four months. This unit is designed for 1500 psig and 1000/1000 F superheat and reheat temperatures from 750,000 to 554,000 lb per hr. Daily output varies between 260,000 and 750,000 lb per hr. No superheater spray-water injection is used during normal full-load daytime operation, except for infrequent short intervals during which it rarely exceeds 0.6 per cent; it may reach a maximum of 2.0 per cent at some partial load points. At 260,000 lb per hr superheater outlet temperature is 975 F, and corresponding reheater temperature is 930 F.

The curves, Fig. 2-C, are from the same reheat installation. In this instance, however, burner position remained fixed, and steaming rate was constant throughout the test run. The variable was the amount of spray water entering the primary desuperheater. Quantity of water actually used was indicated by recording valve openings from closed to fully open position. Under these conditions the superheater shows a greater temperature drop, with increasing spray-water injection, than does the reheater. Actually, the major influencing factor in reheater performance now becomes the lowered steam temperature at the outlet of the high-pressure section of the turbine, rather than any change in gas temperature or quantity at the reheater inlet.

A word of caution is necessary at this point. All the curves in Fig. 2 are qualitative and represent performance of a specific design combination, which can be varied from unit to unit. The magnitude of temperature changes for superheater and reheater will, therefore, be a direct function of these several design variables.

Metal Temperature During Start-up

Many questions have been asked concerning reheater metal temperature during cold start-up. Actual data from a number of installations reveals in every instance that, with normal start-up procedures, this temperature is maintained well within safe limits. Typical are the recorded data shown in Fig. 3 for a 1295-psi and 950/950

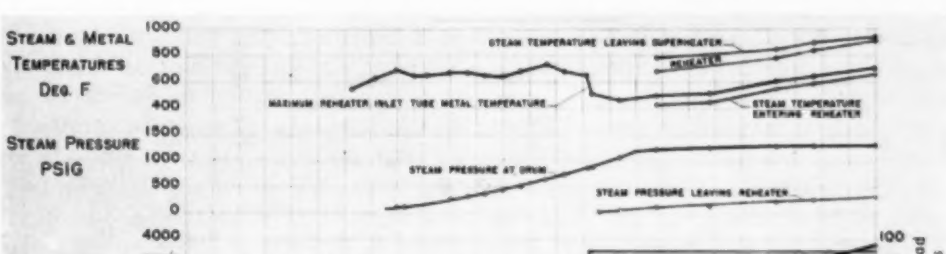

Fig. 3—Curves showing reheater metal temperature during cold start-up of large reheat unit

F unit placed into commercial operation March 18, 1951. In this instance maximum reheater inlet-tube metal temperature did not, at any time, exceed 730 F. This 100-mw unit, together with a companion one started at a somewhat later date, operated continuously during 1952 with an availability of 98.0 per cent. The average hourly generation during this period was 98.4 mw per unit. At 110 mw both primary superheat and reheat temperatures are constant at 950 F without use of desuperheating spray water.

Effect of Sudden Load Interruption

The next important consideration is what happens to the reheater surface in the event of sudden loss of electrical load, at which time steam flow to the reheater is interrupted. A study to simulate these conditions was undertaken by the Niagara Mohawk Power Company shortly after units in its new Dunkirk Station had been placed in service. These units operate at 1492 psi and

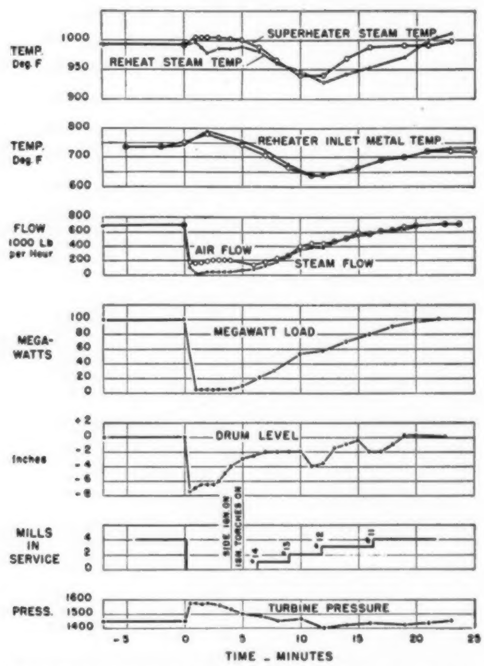

Fig. 4—Conditions recorded during 100-mv trip-out test at Dunkirk Station

1000/1000 F. In this instance, the program involved tripping the entire electrical load, with exception of the station auxiliaries, at three different capacities from 25 to 100 mw. Automatic relays are set to trip firing equipment three seconds after the turbine-control valve reaches a closed position. Normal station procedure for relighting fires was followed. Conditions for the 100-mw trip-out are shown in Fig. 4. Capacity was dropped to approximately 3 mw and after a short predetermined time delay was again restored to the original level. Drop of water level in the boiler drum was 7 in. and was restored to normal, without serious fluctuation, by automatic control equipment. During the no-flow period reheater metal temperature increased 40 to 50 deg F to a maximum of 790 F, which is still well within the limits for safe operation. Both superheat and reheat temperatures dropped approximately 60 deg F after steam was again taken from the boiler for load restoration.

The Dunkirk studies are of considerable value even though made under controlled conditions of load interruption. At the Danskammer Point Station of the Central Hudson Gas & Electric Company, however, there occurred an emergency trip-out at 4:50 p.m. on the afternoon of October 28, 1952. Rated capacity of the turbine-generator is 62.5 mw, and it is served by a reheat unit operating at 1700 psi and 1000/1000 F. This is the only steam-electric unit on what was formerly an all-hydro system. (A second similar unit is now under construction.) The trip-out, resulting from an electrical disturbance, made it necessary to instantly dump the full 500,000 lb per hr capacity of the steam generator. Actual shutdown lasted for one hour and twenty minutes, after which the unit was returned to service at full capacity by 7:30 p.m. During this interruption drum pressure dropped to a minimum of 1400 psi. Water level, except for a momentary drop out of sight, was held at normal level. Superheat temperature dropped from 1000 F to a low of 710 F in one hour and fifteen minutes. Reheat temperature dropped to the same level over a period of one hour and forty-five minutes. Both were back at 1000 F at about 7:30 p.m. The behavior and condition just cited are no different than with any once-through installation.

Operation with Feedwater Heater Out of Service

In the case of reheat installations it may be necessary at times to continue operation with one or more feedwater heaters out of service. Under these conditions the drop in feedwater temperature to the unit results in an increase of gas-to-steam ratio. In addition, pressure, temperature and quantity of steam at the reheater inlet will be changed. Actual effect on overall performance depends upon which heater or heaters are not in use. Experience indicates that when operating at maximum capacity with as many as three top heaters out of service, the effectiveness of burner tilt is more than sufficient to maintain full steam temperature at the reheater outlet. Temperature at the superheater outlet is then regulated by change in spray-water injection.

For practically all installations the top heater receives steam at the crossover point from the high-pressure-turbine exhaust. Steam bled to the heater, at maximum capacity, approximates 10 per cent of throttle flow, which results in about 70 deg F water temperature rise. Use of bleed heating at this point reduces the amount of steam entering the reheater. When this top heater is out of service and the unit continues operating at maximum capacity, a number of simultaneous changes occur. First, there is a reduction in throttle flow to the high-pressure turbine. Since no steam is bled at the crossover point, flow through the reheater increases somewhat, as does also pressure and temperature of the steam at the reheater entrance. Finally, there is a reduction in temperature of feedwater supplied to the unit. The net result of these changes in operating conditions, when the top heater is out of service, is to require an increase of approximately 1 per cent in total heat input to the steam-generating unit. There is also redistribution of heat absorption throughout the unit. The saturated steam section requires greater heat input because of lower feedwater temperature, and the superheater requires a somewhat reduced input because of reduced steam flow. The reheater, however, requires only a

slight increase in heat input. Because of minimum change in reheater requirements, burner tilt is practically the same as with the crossover heater in service. Total combined heat input for saturated and superheater sections of the unit is slightly more than 1 per cent higher. There is, however, an actual reduction in heat required for the superheater. Under these conditions it will, therefore, become necessary to increase, somewhat, the superheater spray-water injection.

Unit No. 2 at Russell Station of the Rochester Gas & Electric Corp. formerly had a somewhat different arrangement of feedwater heaters. Heaters No. 4, 5 and 6 were originally interconnected so that when one was taken out of service the remaining two were also inoperative. Steam is bled at six points. With all heaters in service and the unit operating at 65-mw capacity, throttle flow is 440,000 lb of steam per hr at 1465 psig and 1000 F. Feedwater temperature to the economizer is 425 F. Steam temperature to the reheater is 690 F. Heater No. 4 receives steam from the second bleed point on the intermediate pressure element (about 3.0 per cent of throttle flow). Heater No. 5 receives steam from the first bleed point on the intermediate pressure element (about 2.5 per cent of throttle flow). Heater No. 6 (crossover) receives steam from exhaust of the high-pressure element (about 13.0 per cent of throttle flow). With heaters No. 4, 5 and 6 out of service and operating at 65 mw, the steam flow to throttle is reduced to 395,000 lb per hr, steam temperature at high pressure exhaust is 720 F, and feedwater temperature to the economizer drops to 250 F. Thus, when these three top heaters are out of service, it becomes necessary to increase total heat input to the unit approximately 4 per cent. The distribution of heat is altered materially. Combined saturated steam and superheater sections require an increase in heat input of approximately 7 per cent, while that of the superheater section actually falls off to approximately 89.0 per cent. Input for the reheater section is reduced to approximately 86.0 per cent.

It is obvious, therefore, when operating under the unusual condition of three top heaters out of service that burner tilt is still effective for maintaining reheater outlet temperature. Superheater outlet temperature, because of somewhat higher heat input requirement, may be lower because its surface is balanced with that of the reheater for the conditions which exist when all heaters are in service.

Furnace Wall Cleanliness

Another factor that has important bearing on performance of both superheater and reheater is relative cleanliness of furnace water-walls. During operation these walls gradually become coated with sintered ash deposits; and to maintain furnace-outlet temperature, it therefore becomes necessary to tilt the burner nozzles downward as required. When no further burner tilt is available, wall surfaces must be cleaned to restore effectiveness of burner positioning as a means for reheat temperature control. If operation is continued without wall cleaning, it will eventually become necessary to use emergency spray-water injection at the reheater inlet to avoid excess steam temperature at reheater outlet.

Properly placed wall blowers are effective in removing these sintered accumulations and thereby eliminate use of spray water in the reheater and also minimize its use in the superheater. Scheduling of wall blowing, together with periodic observation of burner tilt, is one means for making certain that furnaces are in optimum condition for normal station operation. Recently a control system has been developed whereby the furnace wall-blowing operation may be automatically accomplished. With this arrangement burner-tilt position, spray-water regulating valve at reheater inlet, and furnace wall blowers are interlocked. Automatic operation starts when the burner tilt reaches a preset downward angle. Simultaneously, a warning light informs the operator that burners are approaching the end of their effectiveness and reheat spray-water injection is about to start. Any additional downward movement now starts opening the desuperheating spray valves at the reheater inlet. At this point the automatic sequential soot-blowing system also begins to function. Wall blowing continues until burners have risen to a preset minimum tilt and spray-water injection at the reheater is stopped and also simultaneously reduced for superheat control.

Availability

The foregoing design factors, as well as operating experiences, have contributed to providing modern reheat installations with inherently high availability. Performance of nine coal-fired dry-bottom reheat units, all in service for a year or longer in the period 1950–1951, showed availabilities from 92.60 to 98.63 per cent. These figures include all required outage for annual inspection. Information for the period ending Jan. 1, 1953, for these and additional units, was not available at the time this paper was being prepared.

Conclusions

The experiences discussed have been taken from actual operating records of several different units, both natural and controlled-circulation types. Inasmuch as more than thirty units of different sizes, whose arrangement of heating surface, furnace arrangement and method of firing are all of the same general design and have shown the same operating behavior, it may be assumed that this will continue to hold true for the entire size range from 40 mw to 250 mw or larger.

Plant personnel have found these units to be no more temperamental or difficult to handle than once-through units. Addition of reheating has not complicated operation or reduced reliability, and no serious difficulties of any sort have been encountered.

Use of the controlled-circulation principle does not alter any actual steam-generating characteristics except to provide for assured and uniform distribution of water to saturated steam surfaces. It also assists in maintaining uniform water level, even with widely fluctuating loads, and thereby contributes to maintaining high steam purity.

Controlled-circulation is usually indicated when operating pressure reaches a level where the thickness of furnace wall tubes normally employed for natural-circulation designs is such that hot-face temperature stress too closely approaches safe allowable limits. The remedy is, obviously, to employ smaller diameter tubes so that thickness is reduced, thereby resulting in lower stress and larger margin of safety.

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Prime Mover Advances Feature ASME Spring Meeting

As a part of the celebration in honor of the Sesquicentennial of the State of Ohio, the Spring Meeting of the American Society of Mechanical Engineers was held at the Deshler-Wallick Hotel in Columbus, Ohio, on April 28–30. Frank J. Lausche, governor of the State of Ohio, was the distinguished guest at the Roy V. Wright luncheon and lecture. A wide variety of technical papers was presented, including two important reports on theoretical aspects and applications of the centripetal turbine and three significant analyses of the economic prospects and potential thermal performance of the free-piston gas-turbine power plant.

At the President's Luncheon, **Frederick S. Blackall, jr.**, president of ASME, had as his subject, "For a Stronger, More Dynamic Society." In addition to discussing some of the problems concerning participation by younger members and the significance of a broadened public relations policy, Mr. Blackall urged that more opportunities be developed for effective technical programs at the local level. This sort of action is needed to help meet problems of an expanding technology and to provide a wider audience, in a geographical sense, for outstanding technical papers.

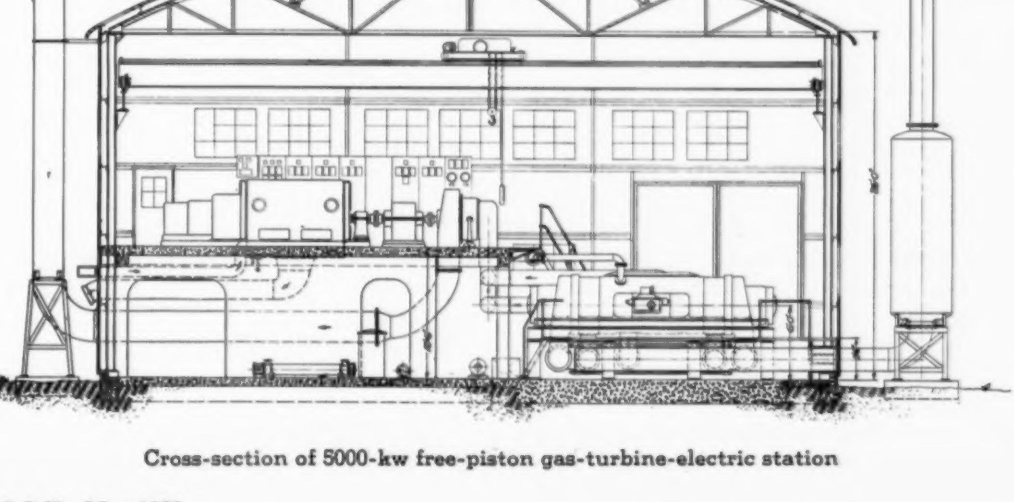
In the Roy V. Wright Lecture **Governor Frank J. Lausche** expressed his admiration for the methods and accomplishments of engineers. In the first place, they deal with indisputable facts, judgments upon which cannot be contradicted and excepted as the facts are present; and secondly they do not occupy the position of a public official who changes his mind in accordance with the expediency of a situation, frequently being unchallenged even though his judgment on one day is completely different from that on another. Tracing highlights of the history of the State of Ohio over the past 150 years, Governor Lausche asserted that the present achievements of the United States of American are due to the fact that the individual is supreme and the government is secondary. Growth can continue only on the basis that the liberties of the human being are preserved. He concluded with this affirmation: "The longer I remain in public office and the more I evaluate life, the more convinced I am that nothing is of consequence except the right to enjoy those powers which were given to us by our God. Take from me my land and my property, but don't take from me the right to think and to work and to express myself, and to pray and to be free from abuses in the courts. Let me be a free man. If you give me my freedom, I will have a chance to rise."

Free-Piston Gas Generators

The free-piston gas-generator-turbine power plant consists of a gas generator producing high-temperature and high-pressure gas which is used to drive a turbine. The gas generator has two opposing pistons which compress their own air for scavenging and charging a single power cylinder.

Under the auspices of the ASME Gas Turbine Division three significant papers were presented on the fundamentals and basic applications of free-piston generators. These papers discussed thermodynamic considerations, reported on tests in France and by two American companies, gave information on design features and problems and contained a preliminary economic evaluation for applications to electric power generation, pipeline pumping and marine installations.

In the first of these papers, "The Free-Piston Type of Gas-Turbine Plant and Applications" by **J. J. McMullen** of the Bureau of Ships, USN, and **Robert P. Ramsey** of The Cooper-Bessemer Corp., the authors described many features of free-piston gas generators. Navy interest in these generators dates back to 1942, with emphasis directed primarily toward gas generators of high specific output and low weight. The paper, how-



Cross-section of 5000-kw free-piston gas-turbine-electric station

ever, is directed mainly to analyzing some of the latent possibilities in heavy-duty free-piston machinery. By way of comparison a free-piston machine for marine service weighs about 30 lb per hp when normally aspirated or 20 lb per hp when supercharged and is designed structurally as heavy as a 100 lb per hp motorship diesel.

The basic feature of the free-piston gas-turbine prime mover is the combination of the high thermal efficiency of the reciprocating internal combustion engine and the high-speed roating power takeoff provided by the turbine. The basic design and thermal cycle are simple, and low maintenance cost is anticipated because of the small number of operating parts. The free-piston generator may attain a pressure ratio over atmospheric at the end of compression as high as 100:1 with an ideal Brayton-cycle efficiency of 69.7 per cent, compared to a corresponding efficiency of 37.2 per cent for a single-shaft non-regenerative-type gas turbine on an open cycle burning fuel at a pressure ratio of about six times atmosphere.

For central-station application an analysis was made of a 5000-kw unit comprised of one gas-turbine-generator with three or four gas generators, all considered as one assembly. When fired with bunker C oil or gas, the unit is expected to have a generator-terminal fuel rate of 9500 Btu per kwhr, assuming a gear efficiency of about 98 per cent, a turbine efficiency of 85 per cent and an alternator efficiency of 96 per cent. Estimated capital investment for a 10,000-kw station, including cost of land and improvements, structures, equipment, contingencies and overhead is $1,818,200, or an average cost of $182 per kilowatt. The following advantages are claimed for this type of installation:

(1) High thermal efficiency, even at low power.

(2) A high-speed drive permitting the use of compact, low-cost electrical equipment.

(3) The possibility of several gas generators discharging into a common gas turbine.

(4) Low initial maintenance and operating costs.

(5) Rapid control of output.

(6) Ideal adaptation to standby or peak load service.

A second economic study was made on the application of the free-piston power plant to pipeline pumping. For a 15,000-hp installation, including cost of land, structures, equipment, contingencies and overhead, estimated cost was $143 per brake horsepower.

"Performance of Free-Piston Gas Generators" was the title of a paper by **Commander McMullen** and **Warren Payne** of the U. S. Naval Engineering Experiment Station, who presented test data on two designs, the Sigma Model GS-34 gas generator and the Baldwin-Lima-Hamilton Model B gas generator. The former operates at 600 cycles per minute with exhaust conditions of 50 psig, 945 F. Based on the higher heating value of 19,600 Btu per lb of fuel, this French-built unit had a maximum thermal efficiency of 32.4 per cent on a shaft horsepower basis. Operating conditions for the B-L-H unit, which has a maximum frequency of 1035 cycles per minute, are 90 psig, 1295 F at the exhaust. Its maximum thermal efficiency at the gasifier discharge was 40.3 per cent (by comparison to the Sigma maximum of 38.2 per cent under different conditions) and on a shaft horsepower basis was 32.2 per cent, making allowance for power to auxiliary equipment.

The following methods may be used to increase the specific output of free-piston gas generators:

(1) Supercharging of power cylinder.

(2) Improvement of port timing.

(3) Higher operating pressure.

In discussing future possibilities the authors stated that operational data have shown that the thermal efficiency of modern diesel engines can be surpassed with a power plant of no greater bulk or weight, fewer working parts and reduced cost and time of construction. As currently available the free-piston unit is the result of comparatively little development. Thus far only seven gas generators have been constructed, but two models now appear ready for commercial exploitation. These models have not reached the stage of perfection that may be anticipated with additional development but they are commercially competitive. By supercharging the power cylinder, outputs approaching twice those now attainable may be obtained with little increase in severity of operation.

The third paper in the series, "The Development of High-Output Free-Piston Gas Generators," was prepared by **Frank M. Lewis** of the Massachusetts Institute of Technology and **Robert A. Lasley** of the Baldwin-Lima-Hamilton Corp. The latter organization has been engaged since 1943 in the development of a gasifier of high specific output suitable for naval propulsion or other applications requiring lightweight machines. Weight and volume of this type plant is influenced by (1) the size and number of gasifier units used, (2) the arrangement of the parts of the gasifier, (3) the pressure and temperature of the cycle, (4) the piston speed of the gasifier and (5) the type of material used and the thickness of stressed parts.

In addition to an extensive description of design details of Baldwin-Lima-Hamilton Models A and B, the authors mentioned that two of the gasifiers had been operated feeding a turbine. These tests were made largely to gain experience. The gasifiers were connected by independent lines, and no difficulty was experienced from the presence of pressure waves in the piping.

Discussion

There was widespread approval of the basic philosophy of the three papers, along with the feeling that the hot-gas generator (of which the free-piston compressor is one type) had received neither the attention nor the research support that it merits. A strong plea was made that the free-piston gas-turbine power plant be evaluated objectively from the outset, so as to avoid extravagant claims based more on enthusiasm than actual experience and accomplishments.

It was reported that 70 of the French Sigma gasifiers have been constructed or are on order. Of these, 44 are for the propulsion of naval vessels; 4 for the propulsion of costal vessels; 1 for a locomotive power plant; and 21 for power generation, with an output range from 600 to 6000 kw.

Looking toward the future, one engineer who had a part in recommending the initial investigations by the U.S. Navy believed that the results discussed in the papers represented an extremely conservative picture. He considered thermal efficiencies on the order of 50 per

cent feasible with materials now available, and indicated that there is a strong possibility of achieving 60 per cent thermal efficiency. More competition among engineers would accelerate the development of higher thermal efficiencies, in his opinion.

Another engineer mentioned the competitive relationship of the conventional gas-turbine plant and the free-piston gas-turbine plant. Both types are advancing, though considerably more research funds and efforts have been expended on the combustion gas turbine than on the free-piston machine. Any evaluation of respective merits must recognize that the competitive relationship is dynamic, not static, with the outcome at least partly dependent upon development results.

In response to a question inquiring as to the feasibility of constructing gas generators for power plants of 10,000 to 20,000 kw and larger, Professor Lewis stated that it is theoretically possible. Some difficulty may be anticipated in fuel injection, but a compensating factor is that larger machines have slower cyclic speed, thus giving more time for combustion.

Centripetal Turbines

In a paper entitled "Some Theoretical Aspects of Centripetal Turbines" **Richard L. Robinson** of the AiResearch Manufacturing Co. derived a general one-dimensional solution for an idealized machine. Apart from his mathematical treatment of the subject the author attempted to clarify technical terminology. In the paper "centripetal" is used to mean that the flow is moving in a general inward direction, but it is not necessary that the flow passage be directed toward the axis of the wheel. This means that the blading in the turbine can be other than radial, as the term "radial turbine" might imply.

Most centripetal turbines in use today change the flow from inward radial to axial at the turbine discharge. Actually the designs analyzed in the paper might be classed as normal centrifugal compressors with the flow and direction of rotation reversed. To the best of the author's knowledge the centripetal turbine is not used in any aircraft power plant but has found considerable application for auxiliary aircraft power.

Rudolph Birmann presented a paper entitled "The Elastic-Fluid Centripetal Turbine for High Specific Outputs" in which he showed that centripetal turbines can be designed to handle larger flows and higher enthalpy drops at higher rpm with better efficiency and lower stresses than the axial-flow turbine. In the hydraulic turbine field the centripetal turbine is best known as the Francis type and has been widely used for about a century. For elastic fluids its counterpart was first conceived in 1928 when the De Laval Steam Turbine Co. undertook a study dealing with its possible applications and subsequently built two experimental units.

The high specific-speed centripetal turbine is characterized by fewer blades than the axial-flow turbine, 20 to 25, compared to 75 to 150 for the latter. Even though the number of blades is low, they are sufficiently wide to permit axial loading to be held to conservative values.

An installation was described in which a three-stage steam compressor was directly connected to a two-stage turbine arranged in a common housing. The compressor was designed to compress 20,000 lb of steam per hr from 375 to 625 psig, this being accomplished by the expansion through the turbine of 10,000 lb of steam per hr from 375 psig to 28 in. vacuum.

The author summarized the disadvantages of the centripetal turbine in the following terms:

1. It usually occupies greater axial space than the axial-flow type.
2. The fact that the motive fluid approaches the blades in a radially inward direction is disadvantageous in that it necessitates the arrangement of stationary-flow passages outside the turbine wheel, making the unit more bulky.
3. Multistaging can be employed but is not as simple as in the case of axial-flow machines.

Advantages may be summarized as follows:

1. It is capable of handling larger flows and/or operating at higher rpm under conditions of equal rotor stresses.
2. It is capable of efficiently handling larger stage enthalpy drops.
3. It has a higher turbine efficiency because (*a*) expansion takes place against centrifugal force, (*b*) the Reynolds number is higher and the Mach number is lower, (*c*) blades can be designed with all-radial sections for balanced flow and (*d*) kinetic energy leaving the blades can readily be recovered by means of a simple diffuser.
4. This type is simpler and cheaper to manufacture and has a more rugged construction because of the low number of blades. Also blades and hub can easily be made as a single piece.
5. It has a low moment of inertia, permitting more rapid acceleration.
6. Blades and hub can be effectively air-cooled in a simple manner.

Discussion

It was brought out that one of the primary applications of the high-specific-output centripetal turbine is single-stage operation in connection with gas turbines and superchargers. An early and very successful installation using steam was to drive a compressor which compressed about 20,000 lb of steam per hr from approximately 375 to 625 psig for use in turbine testing. A brief report was made of exhaustive tests conducted about 12 years ago by a prominent turbine manufacturer in which centripetal wheels were compared to axial-flow wheels under very low steam pressures with rather wet steam. These tests disclosed, among other results, that for the particular conditions the centripetal turbine operated at speeds many times greater than the axial flow machine and that the advantages of the one over the other were not very conclusive.

Chemical Cleaning in Central Stations

A comprehensive survey of chemical-cleaning practices was presented under the above title by **P. H. Cardwell** of Dowell Incorporated. There are five techniques which may be used for removing deposits of scale, oxide and sludge: soaking procedures, jetting at high pressures, spraying of thin and thick solvents, circulation methods

and cleaning while in service. Selection of suitable techniques depends upon the shape and size of the unit being cleaned, and the amount, the hardness and the chemical composition of the scale being removed.

When the equipment is capable of supporting the weight of the solvent and the surface area being cleaned is relatively large in relation to the liquid volume of the unit, it usually is advisable to fill the equipment with the solvent. In such treatments the solvent is left within the unit until the deposit has been removed, either by dissolution or disintegration.

The high-pressure jet is normally used when the scale is not sufficiently soluble in a chemical solvent for removal, or when the deposit is of such a quantity that it is not economical to remove by the soaking technique. The spraying technique finds use on large units lacking structural strength for filling or where the surface area of the unit is relatively small in relation to the liquid volume required to fill the unit. Circulation is employed for cleaning rather small systems in which the solubility of the deposit is usually not very high but disintegration is satisfactory for removal or the amount of deposit present is of such magnitude that one filling of solvent is not sufficient to remove it. The technique of cleaning a piece of equipment while in service has not been employed to any great extent in central stations.

Improved acid inhibitors are now being used in the acid solvents. It has been found that polyethanol amine products give better protection than coal-tar nitrogen-sulfur inhibitors.

Oxygen Solubility

A paper entitled "The Solubility of Oxygen in Water" was prepared by **L. M. Zoss** of Taylor Instrument Co., **S. Suciu** of the General Electric Co., and **W. L. Sibbitt** of Purdue University. The measurements were taken at pressures of 1000, 1500 and 2000 psia and at temperatures from 32 to 625 F. It was found that oxygen shows unusually high solubility at 32 F. This solubility decreases with increasing temperature in the range from 32 to 200 F and then increases with increasing temperature.

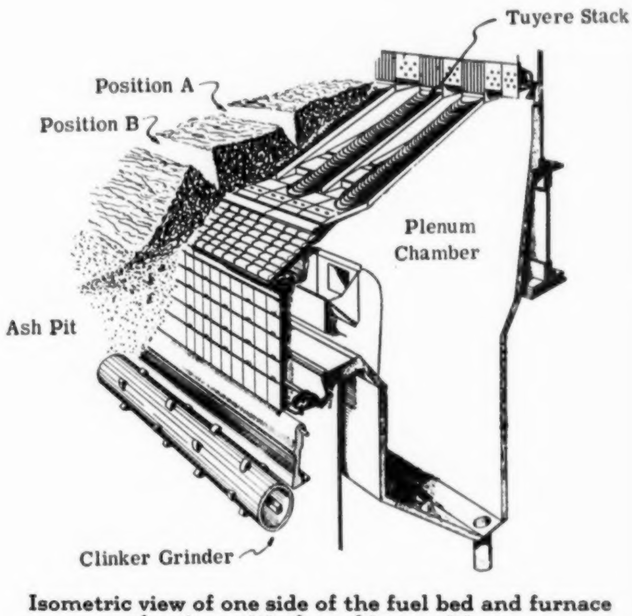
Overfire Air

In a paper entitled "Overfire Air Installation at the Conners Creek Power Plant," **James W. Campbell** and **Richard J. Travis** reported on the installation of overfire air for nine large multiple-retort-stoker-fired steam generators. At this plant of The Detroit Edison Company intermittent smoke emission has been a constant problem since 1934. The combustion chamber heat release at maximum boiler capacity of 420,000 lb of steam per hour is 50,800 Btu per cu ft per hr.

Heaviest smoke usually occurred during and immediately after ash grinding and at breaks in the fuel bed, positions A and B in the accompanying illustration. After grinding, an excess amount of air passed through this break and caused the adjacent fuel bed to smoke heavily because of inadequate air. Also, sudden drops of fuel occurred at this time in the ash pit, and portions of the fuel bed as large as a bushel basket would break loose and fall into the void. As this material hit the bottom of the pit it smashed into pieces and released large quantities of hydrocarbon vapors. Because of insufficient oxygen, puffs of smoke immediately occurred.

An installation was made to blow overfire air between the waterwall tubes at the two points where breaks in the fuel bed generally took place. The air jets were located 12 to 14 in. above the normal top of the fuel bed and had a cross-section of about 60 sq in. The ducts that carry the preheated air downward to the plenum chamber passed directly by the desired jet locations, permitting a simple design for the installation of manually operated overfire air dampers. With $4^1/_2$ in. of water pressure in the duct and the dampers fully open, the initial velocity of the air through the jets is about 10,000 ft per minute.

Tests were made of the effectiveness of the installa-



Isometric view of one side of the fuel bed and furnace showing critical smoking positions

tion as soon as it was completed on the first steam generator. The fuel beds were made heavy by overfeeding and then disrupted by ash grinding, causing the fires to become heavy and smoky. By opening the dampers ten per cent the smoke was almost completely eliminated within seconds. On another test it was possible to eliminate a smoky condition covering the entire fuel bed by opening the dampers on one side of the furnace.

Discussion

Mention was made that this application indicated the soundness of the ideas and recommendations set forth in the Bituminous Coal Research manual on overfire air. However, it was pointed out that there was very careful observation of the region in which smoke formed before steps were taken to correct the condition by applying jets to the trouble area. Without this preliminary study of conditions, application of overfire air would not necessarily have been effective. A number of engineers cautioned against applying this specific solution to other problems of smoke emission without making a new study.

Manual control for overfire air was chosen because the operator necessarily would have to use the observation doors to determine smoking condition. He could then turn and move several feet away to adjust the dampers

and at the same time have a view of stack conditions by means of mirrors. Also, because of the arrangement of two boilers per stack, it is necessary to observe combustion conditions individually in each boiler and make the type of stack observation and overfire-air damper adjustment previously noted. In any case, the dampers are closed when the stack smoke appreciably decreases following earlier adjustment. Overfire air can be applied for as much as half an hour, but normally the dampers are left open a much shorter time.

Mill Drying of Coal

In a paper entitled "Mill Drying in Pulverizing High-Moisture Coals" **Wayne C. Rogers** of the Riley Stoker Corp. stated that success in avoiding pulverizer capacity reduction due to high moisture depends upon the degree and duration of raw-coal and air-mixture turbulence and thermodynamic evaporative effects as well as the amount of heat supplied for evaporation of moisture. High-moisture coal is troublesome only when free moisture exceeds 8 to 10 per cent. On an average installation this might amount to about 15 days per year. Since the occurrence is only occasional, the difficulties of handling and feeding such coal may be overcome by proper use of manpower and mechanical aids to keep the coal moving. However, once the coal enters the pulverizer little can be done to overcome the adverse effects except to tolerate the usual capacity reduction and wait for drier fuel.

With respect to the pulverizer itself there are two methods commonly employed to avoid reduction in steaming capacity when grinding high-moisture coal. One is to provide a sufficient quantity of primary air at sufficiently high temperature to dry out at least the surface moisture and to permit discharge of coal at a temperature adequate to avoid troubles resulting from condensation of moisture or sticking of coal in discharge lines. The second method is to provide excess grinding capacity, thus permitting the desired steaming rate when handling high-moisture coal.

Tests were made to determine ways of satisfactorily pulverizing coal having a moisture content as high as 22 per cent and to handle slurry from a pipe line which would be mechanically dewatered to about 18 per cent moisture. In accordance with test results, the following criteria were set forth for handling high-moisture coals within the pulverizer itself:

1. Provision must be made for a region of very high turbulence in advance of the pulverizer. In this zone it is desirable that all of the heated primary air mix with the coal in the most violent fashion possible and with sufficient time to vaporize essentially all surface moisture.

2. To avoid building up of partly dried coal fines within the pulverizer, substantially all drying should take place within the turbulent region.

3. Recognition must be made of vapor addition to the mill transport air as a result of the drying process. There is usually less primary air admitted than when grinding dry coal at the same rate, and higher primary-air temperatures are therefore necessary.

4. Higher primary-air temperatures must be provided than are usually available from air preheaters on

units burning high-moisture coal at normal coal-primary air ratios. In some instances the use of a small separately fired primary air-booster preheater may be economically justified to upgrade primary air temperature.

Spreader Stoker Dust Emission

E. J. Boer of Bituminous Coal Research, Inc., and **C. W. Porterfield** of Pocahontas Fuel Co., Inc., presented a paper entitled "Dust Emissions from Small Spreader-Stoker-Fired Boilers." Tests were carried out at four small plants, the largest of which had units rated at 365 boiler horsepower. Results indicate that dust emission varies greatly at the boiler outlet, the principal factors being the size consist of the coal and the gas velocities through the furnace. These velocities depend upon the rate of heat release, excess air, type of combustion control and furnace configuration.

The tests disclosed that the rate of cinder emission may be reduced as much by proper selection of coal sizes, use of modulating combustion controls and proper control of excess air as by the installation of a dust collector. In plants which receive proper maintenance and inspection and burn coals with a minimum of extreme fines, a low- or medium-draft-loss collector can often be used.

The analysis of the results of the tests includes this summary:

1. Dust emission increases as the quantity of extreme fines in the coal is increased.
2. Dust emission increases with increased heat-release rates.
3. Modulating controls reduce cinder emission by about 20 per cent compared with on-off operation.
4. When firing at high rates spreader stokers require dust collectors. The type of collector is dependent upon size consist, heat-release rate, type of combustion control and amount of excess air.

Estimating Smoke Density

John P. Strange, principal physicist of the Mine Safety Appliance Co., prepared a paper entitled "The Smokescope—An Instrument for Estimating the Density of Smoke in Stack Effluent." In this instrument a reference standard film disk is viewed against the background adjacent to the stack in order to eliminate the effect of differences in lighting. By this means the smoke and the reference film receive light from the same source, and density estimations are unaffected by background variations or by brightness of the day.

To further improve the accuracy with which smoke density estimations can be made, a lens is used to project a virtual image of the reference standard to a focal distance equivalent to that of the stack. This makes it unnecessary to refocus the eye while making a comparison. The stack is viewed through three aligned apertures in a closed tube-like section. These apertures limit the field of vision to the area of the stack and prevent entrance of stray light. The aperture nearest the eye is the unsilvered center spot of a mirror. On the remainder of this mirror is reflected, by means of a mirror and lens, an image of the film showing the shades for various densities of smoke. Thus the eye sees the smoke from the stack in the center surrounded by the reference film for comparison, without the need to change focus.

Burning Pulverized Cinders

John M. Allen of the Fuels Research Division of Battelle Memorial Institute presented a report on a two-year investigation on the possibilities of reducing cinder emission from conventionally drafted locomotives. A centrifugal-type cinder collector was developed, but the problem remained of finding an effective method of disposing the collected cinders. Because direct reinjection into the firebox had not proved satisfactory, it was proposed that the portion of the cinders which would not fall onto the fuel bed, when rejected into the firebox, should be pulverized sufficiently fine to burn in suspension. Tests were then carried out in a laboratory furnace to determine the degree of completion of burning of pulverized cinders as a function of their residence time in the firebox.

During the tests the effects of these variables were studied: fineness of pulverization, furnace temperatures, excess air and extent of preheat. The completion of burning indicated for an arbitrary residence time of 0.25 second in the furnace was increased by (*a*) an increase in the fineness of pulverization and (*b*) an increase in furnace temperatures under normal conditions of 25 to 30 per cent excess air. Preheating the air supply and the pulverized cinders to 600 F had a beneficial effect on the initial burning rate, but had very little effect on the ultimate degree of completion of burning.

Expert Sees Economic Atomic Power 10 to 15 Years Off

DESPITE current forecasts of commercial atomic power within five years, one of the nation's top atomic power experts recently predicted that it would be 15 years or possibly double that time before atomic power plants will compete on a sound economic basis with coal-, oil- or gas-fired plants. This view was expressed by Harry A. Winne, General Electric vice president of engineering, in addressing the Diamond Jubilee Convocation at Case Institute of Technology on April 10. He added further that one should not expect atomic electric power at very low costs.

Mr. Winne urged that the country's scientific and technological development be on the basis of an orderly, well-thought-out program, with due regard for conservation not only of money, but of that much rarer commodity, scientific and engineering manpower. He also expressed the hope that the Atomic Energy Commission and the Congress would soon begin to consider steps which might be taken, without in any way jeopardizing national security, to relax some of the stringent restrictions in the present Atomic Energy Act. An evidence of some activity looking toward this end would greatly stimulate industry's interest in the whole atomic energy project.

Gadgets vs. Industrial Applications

Classing the atomic bomb and the nuclear-powered submarine as "gadgets," Mr. Winne said that gadgets can be built quickly by a "crash" program with unlimited funds, but sound industry cannot. While conceding the possibility of constructing a large electric power station within the next five years, if built on the gadget basis at terrific cost, he believed that from 15 to 30 years would be required to develop it on an industry basis.

Studies now being conducted by four or five industry groups or teams under contracts with the Atomic Energy Commission will provide a great deal of very useful data, but Mr. Winne doubted they would give the real answers to the basic economic problem of building atomic-electric power plants. His reason for this doubt is that he expects that these studies, based on an atomic pile which produces both plutonium for weapon purposes and heat to generate power, will show such installations as able to produce electric power at competitive costs only if the power is essentially a by-product of plutonium production. The U. S. Government is the only customer for plutonium at present. So, presumably, such plants could live economically only so long as the Government guarantees the market and price for plutonium—a situation that does not constitute a sound basis for an atomic-electric power industry. Such an industry will be economically sound only when it can compete with conventional electric power without requiring a government-supported weapons market.

Fuel Costs

In discussing costs, Mr. Winne said that, of the average price a consumer pays for electric power today, only about 20 per cent represents the cost of fuel, so even if the atomic fuel costs were zero, there would be no hope of fulfilling the forecasts of some of the overenthusiastic, early atomic prophets for low-cost power.

He saw little difference in operating costs of atomic power from that of conventional plants. The major cost problem is the first cost. Since the atomic pile will replace only the boiler and fuel-handling equipment, their cost is the target. In a large modern power plant, this amounts to from $75 to $100 per electrical kilowatt capacity. Public knowledge of corresponding atomic pile costs is rather meager. An Atomic Energy Commission executive said in May 1950 that the average cost of four then-projected large research reactors was approximately $10,000 per equivalent electrical kilowatt. In December 1952, another AEC speaker estimated the cost for the atomic plant in the first nuclear-powered submarine to be of the order of $1400 per kw, and a fairer figure for a land-type plant might be $500 to $600 per kilowatt. From this, it will be noted, the estimated cost has dropped considerably and is likely to drop further as knowledge and experience in building such nuclear power plants are gained.

In fact, Mr. Winne believed it would ultimately be possible to build atomic-electric power plants which can compete economically with coal- or oil- or gas-fired plants; but this, he said, is going to take a long time, probably measured in decades rather than years as some have predicted.

Process for Utilizing Western Lignite

A PROCESS for utilizing the vast lignite and subbituminous coal reserves of the American west as a source of cheap electric power and coal tar products is described in detail for the first time in a Bureau of Mines report just released.

Based on the Bureau's experimentation, the Texas Power & Light Co. is building a central electric power plant in Milam County, Texas, that can use Texas lignite and also provide for Alcoa's new aluminum-smelting plant, opened in November 1952. Fuel derived by this process is expected to compete with natural gas at prevailing prices. It will be about a year, however, before the Alcoa plant begins drawing on the new power source.

Known as coal carbonization in a fluidized state, the process represents two years of research by the Bureau of Mines in cooperation with the Texas Power & Light Co. Experimentation was carried out at the Bureau's pilot plant in Denver, Colo.

The major object of the Bureau's investigation—conducted from 1949 through 1950—was to develop a technology for carbonizing lower rank western coals so that valuable tars, the source of many basic chemicals, could be separated from their residue. The charred residue, however, acts as the boiler fuel that can be used eventually to produce thermal electric power. The report deals largely with a description of this process. It also gives basic detail data on the processing of eleven typical fuels, all low-rank and noncoking.

Part of Comprehensive Program

The Bureau's research on lignite is part of its overall program of expanding the use of the large reserves of these low-rank, noncoking western coals—a program greatly accelerated during World War II. Lignite is significant as a fuel because it is near the surface, is cheap and abundant (an estimated 712 billion tons), and represents about one half the total coal reserves of the West. The other half is subbituminous, also usable in this process.

As a result of the Bureau's process, however, a new horizon has been opened, making lignite and subbituminous coal commercially promising on a large scale. Often called "fluidized carbonization," the new process is a variation of low-temperature carbonization and yields a char of high heating value for power plant use and crude primary coal tar. It is also a possible future source of byproducts such as drugs, dyes, plastics and explosives—products which now come from coke oven tar.

Earlier Bureau reports on experimental work conducted at Denver described the theory and practice of removing inherent moisture from lower rank coals, but did not include a study of how surface moisture is removed from the fine fuel. The present report deals largely with carbonizing fine coal after drying, and gives results of pilot-plant investigations on low-temperature carbonization of several typical noncoking fuels.

Fluidized, or entrained, drying is merely a process of mixing fine coal with hot gases in such proportions that the resultant mixture reaches a temperature of 275 to 325 F. After the coal has been in this environment long enough, 90 to 95 per cent of the inherent moisture is evaporated. This takes approximately 50 sec. The velocity of the gas and the size of the drying chamber are other important factors in drying.

To carry out the research, the Bureau developed two pilot plants in Denver—one of 5 tons-per-day capacity and a larger integrated unit of 25 tons-a-day, where the drying and carbonizing operation is run in sequence. The commercial power plant now being built in Texas will use about 1000 tons of lignite a day in each of nine units comprising the lignite processing part of that plant.

Prepared by V. F. Parry, chief of the Bureau's Coal Branch in Denver, W. S. Landers, fuel technologist, E. O. Wagner and J. B. Goodman, chemical engineers stationed at Denver, and G. C. Lammers, chemical engineer employed by the Texas Power & Light Co., the report contains results of assay tests on different coals tested.

Electric Output, Capacity and Fuel Consumption

Figures issued by the Federal Power Commission on March 30, 1953, show a total output by electric utilities for the twelve months ending February 28, 1953 to have been 403,444,974,000 kw-hr, an increase of 7.1 per cent over the preceding twelve-month period. This was the highest total yet attained for such a period. The proportion produced by fuel-burning plants continues to increase, the figure for February being 73.2 per cent.

Reports received during March indicate an installed electric utility capacity of close to 83 million kilowatts which figure was some seven million kilowatts over that of a year earlier. The total industrial electric generating capacity reported amounted to 15,199,000 kw.

The coal consumption by electric utilities represented an increase of 4.7 per cent over that of February 1952, whereas fuel oil consumption was 42.6 per cent higher and gas 5.5 per cent.

On March 1 there were sufficient stocks of coal on hand at utility plants to last 121 days whereas fuel oil stocks on hand represented a 54-day supply.

Average fuel consumption per kilowatt-hour continued to decrease slightly and is now 1.08 lb of coal.

Air Pollution Meeting in Baltimore

The Annual Meeting of the Air Pollution Control Association will be held at the Lord Baltimore Hotel, Baltimore, from May 25 to May 28, and will begin with a luncheon followed by a boat trip along the harbor front.

The technical program will cover a variety of interests including several papers on railroad air pollution control, talks on air pollution instrumentation by W. B. Harris of the Atomic Energy Commission, Dr. David Sinclair of Johns-Manville, Dr. Paul L Magill of Stanford Research Institute and Moyer D. Thomas and J. O. Ivie of the American Smelting and Refining Co.

Both coal and oil are being covered in a number of papers, and four others on incineration will be presented. Stack gas dispersion and stack design will be the subject of a paper by Dr. W. N. McDaniel and H. C. von Hohenleiten, both of the Consolidated Gas, Electric Light & Power Company.

Nathan W. Clauss of the Union Carbide and Carbon Corporation will speak on "The Reduction of Atmospheric Pollution of Sulfuric Acid Recovery Procedures," while G. A. Howell of United States Steel Company, Pittsburgh, will speak on air pollution control in the steel industry.

E. H. R. Pegg, vice president, and D. W. Gibbs, engineering department, Aerotec Corporation, will speak on internal flow problems in mechanical-centrifugal dust collectors, while L. C. Palmer and George E. Best of the Mutual Chemical Company of Baltimore will discuss atmospheric pollution control in a chromium chemicals plant.

"Management Considers Air Pollution" is the subject chosen by Walker Penfield of the Pennsylvania Salt Manufacturing Company, Philadelphia.

The traditional association banquet will be held on the evening of May 27 in the Lord Baltimore ballroom.

Performance of British Power Stations

The British Electricity Authority reports that over 1,300,000 tons of coal were saved last year by increased efficiency in the steam stations under its jurisdiction. The overall average thermal efficiency of these stations, nearly 300 in all, for the calendar year 1952 was 22.61 per cent, compared with 21.79 per cent in 1951. The improvement in thermal efficiency (0.82 per cent) not only represents a great saving in coal consumption, but an economy in cost of over £3,000,000.

The following tabulation lists the twenty steam power stations having the highest overall thermal efficiency for 1952. Three other stations, namely Brunswick Wharf, North Tees C and Huncoat, which did not operate throughout the whole year, achieved thermal efficiencies for their periods of commercial operation of 28.41, 26.93 and 26.60, respectively.

New power stations and extensions to older stations make a highly important contribution to national fuel economy. Well over one-tenth of the Authority's present total output capacity is provided by plants over 25 years old. The replacement of these old machines will save substantial quantities of coal and money.

Station	Thermal Efficiency per cent
Littlebrook 'B'	29.95
Dunston 'B' II	29.96
Portobello H.P.	29.46
Skelton Grange	29.19
Bromborough	28.88
Stourport 'B'	28.84
Battersea 'B'	28.71
Poole	28.31
Breehead	27.79
Agecroft H.P.	27.20
Blackwall Point	26.66
Clyde's Mill H.P.	26.66
Fulham	26.63
Cliff Quay	26.63
Stuart Street H.P.	26.47
Brimsdown B.H.P.	26.41
Hamms Hall 'B'	26.24
Llynfi	26.23
Staythorne	26.18
Croydon 'B'	26.02

N.S.P.E. to Meet in Florida

The National Society of Professional Engineers will hold a three-day meeting at the Sheraton-Beach Hotel, Daytona Beach, Florida, June 18–20. It will be devoted to the professional rather than the technical aspects of engineering and a feature of the gathering will be the presentation of the N.S.P.E. Award to Charles F. Kettering, of General Motors.

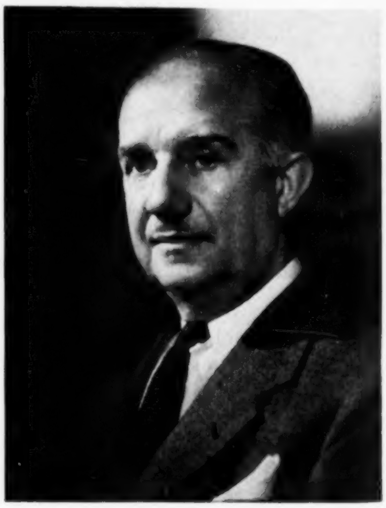
C. E. Elects Officers and Shortens Name

Stockholders of Combustion Engineering-Superheater, Inc. at their annual meeting on April 14 voted to shorten the company name to Combustion Engineering, Inc.

At the same time the Board of Directors elected the following officers to new posts: Joseph V. Santry, president, was elected Chairman of the Board and will continue as chief executive officer; Samuel G. Allen retired as Chairman of

J. V. Santry

the Board but will continue as Chairman of the Executive Committee; Martens H. Isenberg, executive vice president, was elected president, succeeding Mr. Santry; George D. Ellis, vice president and controller, was appointed vice president in charge of finance, succeeding Harold H. Berry who has reached the retirement age. Mr. Berry will continue as a director. W. S. Bencher, formerly assistant controller, was appointed controller, succeeding Mr. Ellis in that capacity.



M. H. Isenberg

Mr. Santry has been with Combustion since 1915 and has served as an officer and director since 1918. He became executive vice president of the former Combustion Engineering Company, Inc. in 1933 and president in 1940. He was elected president of Combustion Engineering-Superheater, Inc. when Combustion was merged with The Superheater Company at the end of 1948.

Mr. Isenberg joined Combustion as an engineer in 1916 and was elected a vice president in 1928. He was made executive vice president in 1940 and has continued in this post up to the present. He was elected a director in 1951.

G. D. Ellis

Mr. Ellis has been associated with Combustion or affiliates since 1915. He was elected vice president and controller in 1948 and became a director in March of this year.

AIEE Meeting at Atlantic City

A program covering advances in the electrical field will feature the Summer General Meeting of the American Institute of Electrical Engineers to be held at the Chalfonte-Haddon Hall, Atlantic City, June 15–19.

The meeting, which is expected to be the largest summer gathering in the history of the Institute, is being arranged by the Philadelphia Section and will mark the celebration of the 50th anniversary of that section.

A conference of delegates from the 98 Sections of the Institute is scheduled for Tuesday, June 16.

Instead of the customary inspection trips, the general committee has concentrated on entertainment programs.

A special effort is being made by the Committee to interest student engineers and arrangements have been made to have at least 40 from various engineering schools attend the meeting as guests of the Philadelphia Section.

Personals

Albert A. Casey, for a number of years general superintendent of plants of the Cleveland Electric Illuminating Company, has been elevated to a vice president of the Company.

Ralph E. Neidig, for the past five years operating superintendent of the Metropolitan Edison Company, Reading, Pennsylvania, has been made chief engineer in charge of the Company's electrical engineering and system planning.

J. K. Kuykendall, until recently chairman of the Washington State Public Service Commission, has been made a member of the Federal Power Commission.

Royston Crewdson of The Kuljian Corporation, Philadelphia engineers, has been made representative of that company in the Far East with headquarters in Tokyo. Prior to his association with Kuljian Corporation he spent six years with the American Administration in Japan under General MacArthur.

Edward W. Legier, since 1933 eastern sales manager of American Blower Corporation, has been made a vice president of that company. He will continue to make his headquarters in New York.

Obituaries

Griswold Denison for more than 25 years mechanical engineer with the New York Steam Corporation and until his retirement six years ago, died suddenly in New York on April 11 at the age of 70. Subsequent to his retirement he became associated for a while with Baker & Spencer, consulting engineers. He was a graduate of Columbia University in mechanical engineering and a member of the ASME.

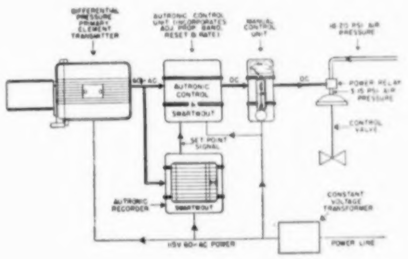
Gano Dunn, president of J. G. White Engineering Corporation for the last 40 years, and widely known for his association with numerous vast engineering projects, died on April 10 at the age of 82. He was chairman of the board of trustees of Cooper Union at the time of his death and was a former trustee of Columbia University.

Neil A. Benson, plant manager of Hagan Corporation, Pittsburgh, died on April 12 at the Dunlap Memorial Hospital, Orville, at the age of 52. Previous to joining Hagan in 1946, he had been works manager of Elliott Company and later assistant to the vice president of General Refractories Company.

NEW EQUIPMENT

Automatic Control System

A differential-pressure primary element transmitter for use in automatic control systems has been developed by The Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio. Designated as Type D2T it is used in conjunction with their Autronic Control System and covers a differential pressure range of

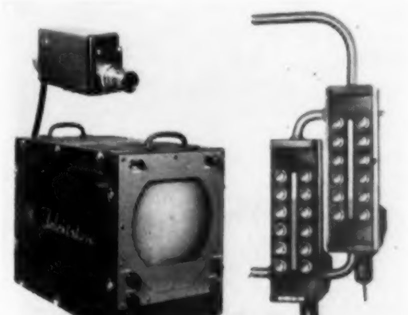


0–20 in. to 0–200 in. of water at static pressures up to 1500 psig. Installed at the point of measurement, the unit transmits an electric signal which is directly proportional to the variable being measured.

Televised Water Gages

Television of YARWAY flat-glass boiler water gages is now available as a result of an arrangement between the Radio Corporation of America, and Yarnall-Waring Company, Philadelphia.

This new application of RCA's Industrial Television to installations of

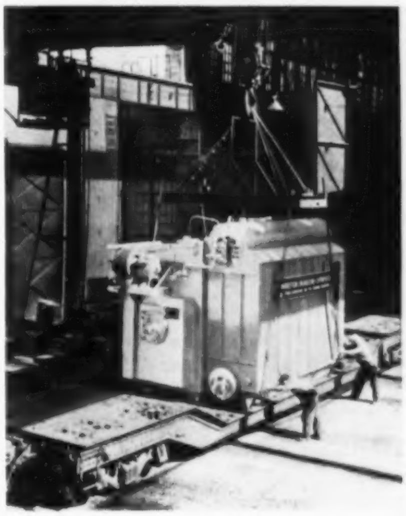


YARWAY pressure sealed flat-glass gages brings "live" gage readings down to the operating panel or any other convenient location in the boiler plant. The television image is transmitted from the small, light-weight camera to the viewing monitor by a single cable. This simplified two-unit chain is standard RCA equipment. The special camera base provided, also furnishes proper lighting of the gages.

Yarway gages, besides the pressure-sealed "floating assembly" feature, also offer for increased visibility a new separated-design advantage with interconnecting expansion loops, YARWAY Welbond gage valves, circulating tie-bar and Type "M" illuminators.

Shop Assembled Package Boiler

A new line of standardized, shop-assembled water-tube boilers is now being offered by Combustion Engineering, Inc., 210 Madison Avenue, New York. Known as the C-E Package Boiler, Type VP, it is a compact unit designed to meet the demand for standardized boilers operating in the



pressure range up to 250 psig and for steam capacities ranging from 4000 to 30,000 lb per hr.

The design employs the two-drum, vertical bent-tube arrangement with a water-cooled furnace. The ratio of furnace-wall cooling to furnace volume is higher than in any other boiler of its size and type. This feature assures rapid and efficient heat absorption and lower gas temperatures entering the convection bank, and should result in less slag formation.

This boiler is designed for pressure firing of oil or gas either alone or in combination. It is completely shop-assembled, ready for shipment as a unit with firing equipment, setting, forced-draft fan and automatic control. For oil firing, steam-assisted, mechanical-atomizing burners are used; ring-type burners are furnished for gas firing. Either type of burner may be added to the air register at any time. Oil pump and heater sets are included with oil burners as standard equipment.

Through the use of a centrifugal-type forced-draft fan, the VP boiler operates more quietly than those units employing typical high-speed blowers. Since this fan supplies air to the furnace at a pressure high enough to overcome the draft loss through the unit, neither a high stack nor an induced-draft fan is required.

Since the unit is completely shop-assembled, it can be skidded or lifted from a railroad car or truck on to a simple foundation as shown in the illustration. Lifting lugs are provided so that it may readily be unloaded and handled by a crane. Installation can be completed in a few days after delivery.

Gage Illuminator

Reliance Gauge Column Co., 5902 Carnegie Avenue, Cleveland 3, Ohio, announces a new boiler-water gage illuminator using an efficient spot-beam mercury lamp. Enclosed in a sheet steel housing which attaches readily to the water-gage insert, the lamp provides a brilliant illumination of the water-level

meniscus. It is recommended for conditions where gages are 40 ft or more from the operating level as well as for lesser heights when bright images are desired or visibility is otherwise impaired.

Electrode Rapping System

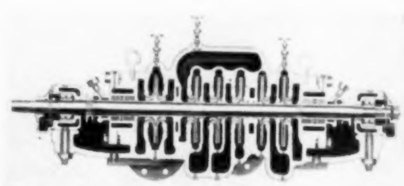
Basic elements of the MI (magnetic impulse) rapping unit for installation in electrostatic precipitators are as shown in the accompanying view. The MI rapping case, containing a solenoid-actuated plunger and its elements, is welded to the end of a horizontal rapper bar protruding through the precipitator wall and stuffing box. Collecting plate-electrodes are grouped into banks, and the horizontal rapper is welded

along the edges of these banks. Each bank is rapped in sequence at a rate of one cycle per minute or less in order to prevent dust accumulations on the elec-

trically charged surfaces of the electrodes. This system for dust-collector cleaning was developed by the Research Corp., Bound Brook, N. J.

Centrifugal Pumps

The accompanying illustration is typical of high-speed, high-pressure centrifugal pumps available from Pennsylvania Pump and Compressor Co., Easton, Pa. It can be seen that the first-stage impeller is of the double-suction type, enabling the handling of hot water with lower net positive suction



head. The stuffing boxes of this design are subject to low pressures only, suction pressure at first stage, and first-stage pressure on the other side of the pump. These units are manufactured with capacities up to 1300 gpm; 5, 6 and 7 stages; heads of 1200 psig; and $2^1/_2$, 3, 4 and 5-in. sizes.

Pressure Gage

Manning, Maxwell & Moore, Inc., Stratford, Conn., have announced the availability of the Ashcroft Maxisafe Duragauge in which an integrally cast solid wall separates the dial from the gage movement and tube. A double spring-mounted safety-release plate covers the entire back of the case, permitting the discharge of the pressure media away from the viewer. Teflon-coated to prevent being painted closed or adherence to the gasket, the safety-release plate fits tightly on a rubber gasket and is held in place by a small knurled knob. The gages come in pressure ranges from vacuum to 100,000 psi, with dial sizes of $4^1/_2$, 6 and $8^1/_2$ in.

Pipe Hanger

Constant support that is said to be mathematically perfect for all positions of travel for high-temperature process and steam piping is supplied by the new Model R constant-support hangers manufactured by the Grinnell Company, Inc., 260 West Exchange St., Providence 1, R. I. A special feature of the design permits an increase or decrease of 10 per cent in hanger load by field adjustment of a single bolt, without impairment of constancy of support. Three regular frame sizes providing maximum travels of 4, 8 and 12 in. will take care of all loads from 48 to 9304 lb. The new design provides favorably small ratios between spring force and supported load ranging from 1.15 minimum to 4 to 1 maximum.

New Catalogs and Bulletins

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Pressure Regulating Valves

The Swartwout Co. has made available a 12-page bulletin covering the company's line of pressure-regulating valves and pressure master controls. Printed in two colors and punched to fit three-ring binders, it is illustrated with photos, cutaway and section views, and dimensional and specification data. It describes diaphragm-operated spring-opening and spring-closing regulating valves, pressure controllers, air locks, valve positioners and selector panels.

Flowmeters

A set of seven specification sheets covers the flowmeter line of the Brown Instruments Division of Minneapolis-Honeywell Regulator Co. There are descriptions and illustrations of two types of electric and mechanical evenly graduated flowmeter bodies as well as several types of square-root flowmeters and liquid-level meters.

Speed-Reduction Drives

"Shaft-King" shaft-mounted speed-reduction units are illustrated and described in a 20-page catalog published by The American Pulley Co. Complete information and dimensions of units are

given along with instructions concerning selection of correct sizes for given applications. Cutaway and phantom drawings illustrate details of construction.

Electrical Insulation

An 8-page booklet on Class H silicone electrical insulation has been prepared by Dow Corning Corp. It includes reports received on operating conditions and performance of electrical equipment insulated with this material. Data are also presented on a motor-test program and typical properties of Class H components.

Rectifier Units

A two-color booklet describing General Electric's line of metallic rectifier power conversion units has been announced as available. The illustrated 8-page bulletin, GEA-5658A, contains design features, performance, circuits, applications and advantages of the line. A chart of dimensions, ratings and weights is also included.

Condenser-Tube Inserts

A four-page bulletin describing condenser-tube inserts has been made available by Thomas C. Wilson, Inc. It explains that condenser tubes usually fail in the first few inches of the inlet. The function of the inserts is to restore the tubes to service by sealing off deteriorated portions. They also are said to retard or eliminate the effect of inlet-end erosion.

Flame-Failure Protection

Combustion Control Corp. has issued an eight-page bulletin illustrating and describing its "Fireton" tube, a photoconductive cell responsive to infrared rays and designed to give instant response to flame failure with oil, gas or pulverized-coal burners. In case of flame failure an alarm is sounded and the fuel supply is cut off electronically.

Hoists

Sauerman Bros., Inc. has prepared an attractive 28-page hoist catalog containing full information on hoists for operating power-scraper excavators and storage machines, slackline cableway excavators and tautline cableways. Among the features described are brake and clutch controls and provisions for remote controls.

Asbestos Insulation

"Quinterra—Quinorgo" is the title of a 32-page Johns-Manville publication which gives information on electrical insulations made of purified asbestos, reasons for development, char-

acteristics and situations in which they may be used to advantage. For the electrical designer there are tables giving test data on physical and electrical properties. Of value to the production man is advice on application techniques and equipment, including step-by-step photographic coverage of methods now in use.

Centrifugal Pumps

Allis-Chalmers single-stage, double-suction Type S centrifugal pumps are described in a recently revised bulletin, designated as 08B6146B. In addition to providing data on the pump's construction features, the bulletin explains how to figure pumping head, carries table of available sizes, approximate dimensions and head capacities, and tabulates friction loss for water per 100 ft of pipe.

Industrial Heaters

A 32-page catalog by the Westinghouse Electric Corp. provides information on standard and heavy-duty centrifugal-fan industrial heaters. It tells where to use heaters, at what circulating capacities and temperatures, and how to place them. One section explains automatic temperature control and tells how to estimate the heat load a particular heater must carry. As an aid to selection, typical specifications are given along with worked-out examples.

Roller Chain

The improved Baldwin assembly-riveted roller chain is described in detail in bulletin No. 52-2 prepared by Baldwin-Duckworth, Division of Chain Belt Co. There is a graphic section showing how the chain is made up to any length. Assembly diagrams and charts for all sizes of chains are presented as well as list prices, strengths, dimensions and weights of standard roller chain.

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If you have any kind of a suspension-recovery problem—whether dust, fly ash, fume, fog or mists—it will pay you to bring it to the leading organization in the field . . . WESTERN PRECIPITATION CORPORATION. Western Precipitation not only pioneered, over 44 years ago, the first commercial application of the now-famous COTTRELL Electrical Precipitators, but also has been a leader for many years in the *mechanical* recovery field with its widely-accepted MULTICLONE Collectors.

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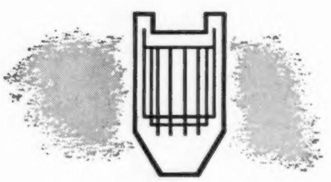
Western Precipitation is unsurpassed in the all-important factor of "know-how" in BOTH the electrical and mechanical fields . . . knows from years of first-hand experience whether your particular problem can best be solved by mechanical or electrical methods—*or by a combination of the two* . . . can give you a direct and unbiased recommendation on the matter . . . and then can provide the complete installation under *one* responsibility, *one* overall performance guarantee, even where Combination Multiclone-Precipitator (CMP) installations are made!

Western Precipitation products and services include . . .



COTTRELL
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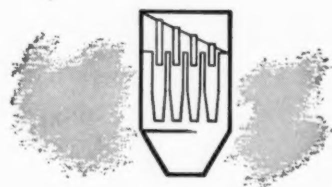
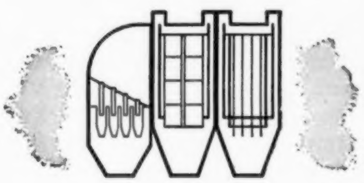
. . . the most efficient recovery equipment for high recovery, long life, low maintenance on practically any type of suspensions, wet or dry. COTTRELLS can be designed to handle a few c.f.m. —or millions—with equal ease, and at virtually any operating temperature. Recovery efficiencies closely approach 100% recovery, if desired, with very low draft loss, minimum power costs and negligible labor costs. *By all standards, Western Precipitation COTTRELLS give highest recovery at lowest cost per-year-of-service!*



MULTICLONE
Mechanical Collectors

. . . the most efficient, most compact, most trouble-free mechanical equipment for recovering suspensions from gases. Because of their unique small-tube design, MULTICLONES are unsurpassed in mechanical recovery efficiencies—require less space, less maintenance, and are far simpler to install. No filters or screens to replace, nothing to burn or cause fire hazards, no high speed moving parts to repair or replace. These and many other advantages make MULTICLONE Collectors the logical choice on installations where mechanical recovery is selected.



CMP UNITS
(Combination Multiclone-Precipitator)

. . . combine, in *one* compact installation, *both* mechanical and electrical recovery principles so that maximum benefit is obtained from the advantages inherent in each method. The MULTICLONE section centrifugally removes the larger and heavier suspensions (down to a few microns in diameter) . . . and the COTTRELL section then electrically removes the very small particles remaining in the gases. Thus, the bulk of the recovery is obtained with relatively low-cost equipment, and the final clean-up is obtained with equipment having unusually high recovery efficiency—approaching theoretically perfect, if desired.

The recovery of suspensions from gases is a highly exact science and every problem is different. Some require mechanical methods—others electrical methods—still others a combination of mechanical and electrical methods in proper balance to meet the individual requirements of each application. No matter what your problem, remember that only Western Precipitation has had years of field experience in BOTH mechanical and electrical methods!

Send for descriptive literature!

Let our experienced engineers study your recovery requirements and make an unbiased recommendation on the equipment best suited to your particular problem. A wire, phone call or letter to our nearest office places this unique "know-how" at your service, without obligation.

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